NEW 2007 night-sky guide bonus pullout inside!

January 2007

Astronomy®

The world's best-selling astronomy magazine

SPECIAL ISSUE

Top 10 stories of 2006

- Pluto demoted
- Comet dust returned to Earth
- New Milky Way satellites
- 200+ exoplanets
- Venus Express arrives
- Touchdown on an asteroid
- **and more!**

At a distance of 1,500 light-years, the Orion Nebula is the closest star-forming region. Hot, young stars create a tapestry of glowing gas and dust. p. 34

PLUS:

All about the Crab Nebula p. 70

Hubble reveals 16 distant exoplanets p. 44

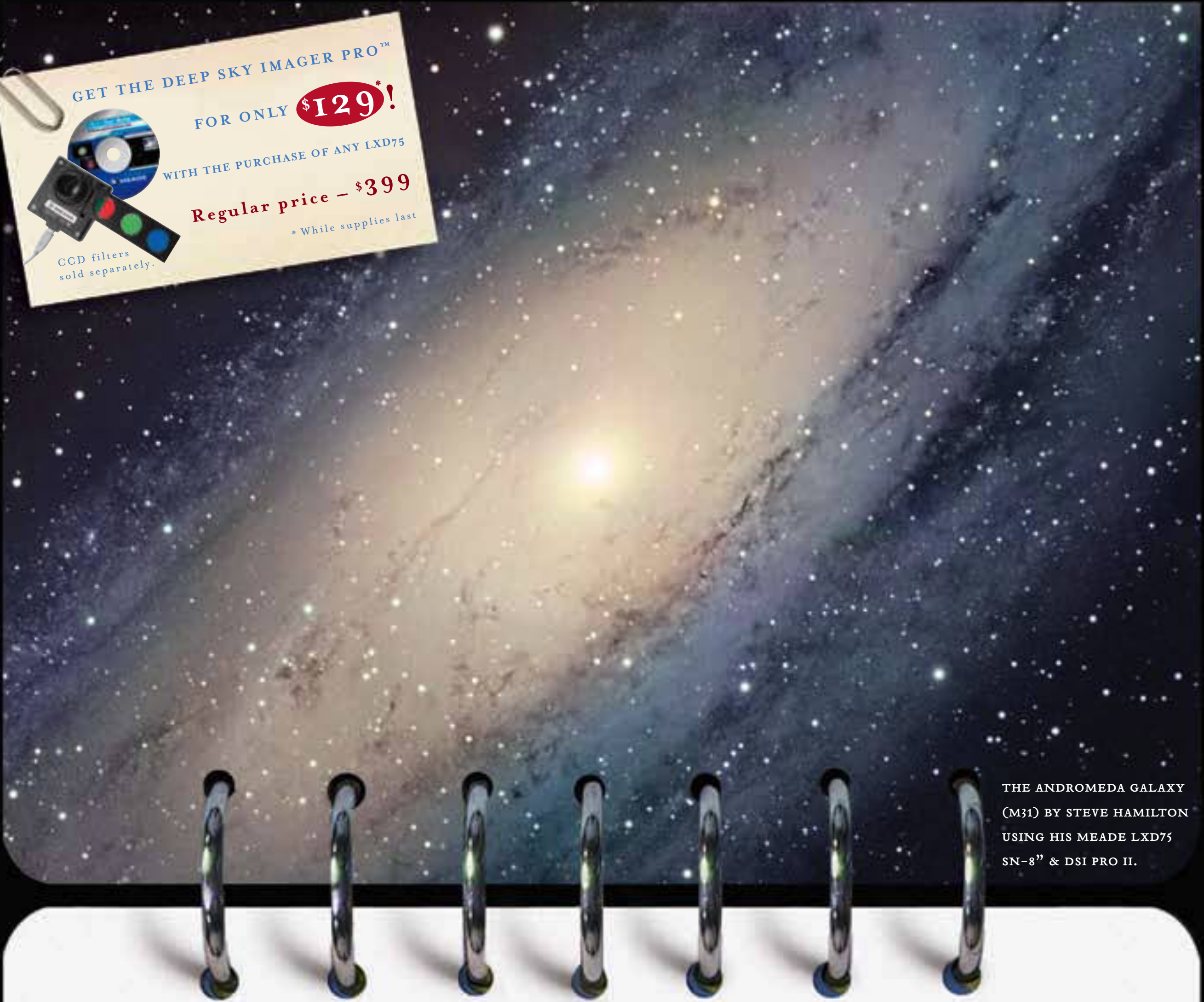
Latest portraits from Mars p. 64

Make Hubble shots your own p. 84

Astronomy.com

$5.95 U.S. • $6.95 CANADA

Vol. 35 • Issue 1


GET THE DEEP SKY IMAGER PRO™
FOR ONLY $129*!
WITH THE PURCHASE OF ANY LXD75
Regular price – $399
* While supplies last
CCD filters sold separately.

THE ANDROMEDA GALAXY (M31) BY STEVE HAMILTON USING HIS MEADE LXD75 SN-8" & DSI PRO II.

"MEADE'S LXD75 SCHMIDT-NEWTONIANS ARE THE BEST KEPT SECRET IN ASTROPHOTOGRAPHY."

The Schmidt-Newtonian optical design is so unique, only Meade makes it. This revolutionary design gives you the best of both worlds: observing and astrophotography. It does it all. The fast f/4 focal ratio is an ideal match for Meade's user-friendly Deep Sky Imagers. These scopes are versatile, portable, and high-tech. Online forums positively rave about the optics. Astrophotographer Steve Hamilton is impressed by "the tack-sharp round stars, exquisit detail, and flat field" of these premium scopes. They are an "astrophotographer's dream." The Schmidt-Newtonian is the flagship of the LXD75 line. Buy one and let the fun begin.

8" Schmidt-Newtonian

MEADE

MEADE.COM | 800.919.4047

6" Newtonian	6" Schmidt-Newtonian	8" Schmidt-Newtonian	10" Schmidt-Newtonian	8" Schmidt-Cassegrain	5" Achromatic Refractor	6" Achromatic Refractor
$799	$999	$1199	$1399	$1499	$999	$1199

Patents: 6,304,376; 6,563,636; and other patents pending.

30-06137

ETX-80
$279
“The coolest thing we saw in Mexico was Saturn.”
Camping out is a great way to see the world. Just remember that some of nature’s grandest sights are directly over your head.

New **2007 Meade Catalog** is here!

Download or order the
150 page catalog at
meade.com/catalog

THE ETX-80™ ULTRA-PORTABLE GO TO TELESCOPE

Ever get so far away from the city that the stars look like you could reach out and touch them? Wish you could get just a little closer? Now you can. The ultra-portable ETX-80 is the perfect campground observatory. It’s ideal for camping, hiking, picnics, the beach, vacations, or any other time you want to connect with nature and the universe. You can study the craters of the moon, the rings of Saturn, the moons of Jupiter, plus hundreds of galaxies, nebulas, double stars, clusters, you name it. It’s also the perfect scope for daytime bird and nature watching too!

MEADE.COM | 800.919.4053

TELESCOP S.C2M 800.958.6030•) ASTRONOMICS (800.356.6603) • B & H PHOTO (800.329.0315)
OPT CORP. (800.338.9638) • DURANGO SKIES (970.259.5400) • ADORAMA (800.223.2500)
SKIES UNLIMITED (888.947.2673) • CANADA – KHAN SCOPE (800.580.7160)

MEADE®

30-06140

NEW 2007 night-sky guide bonus pullout inside!

January 2007

Astronomy

The world's best-selling astronomy magazine

SPECIAL ISSUE

Top 10 stories of 2006

- Pluto demoted
- Comet dust returned to Earth
- New Milky Way satellites
- 200+ exoplanets
- Venus Express arrives
- Touchdown on an asteroid
- **and more!**

At a distance of 1,500 light-years, the Orion Nebula is the closest star-forming region. Hot, young stars create a tapestry of glowing gas and dust. p. 34

PLUS:
All about the Crab Nebula p. 70
Hubble reveals 16 distant exoplanets p. 44
Latest portraits from Mars p. 64
Make Hubble shots your own p. 84

NASA/ESA/STScI/M. ROBBERTO; INSET: NASA/STScI

ON THE COVER

CENTER SECTION

34 Top 10 astronomy stories of 2006

70 All about the Crab Nebula

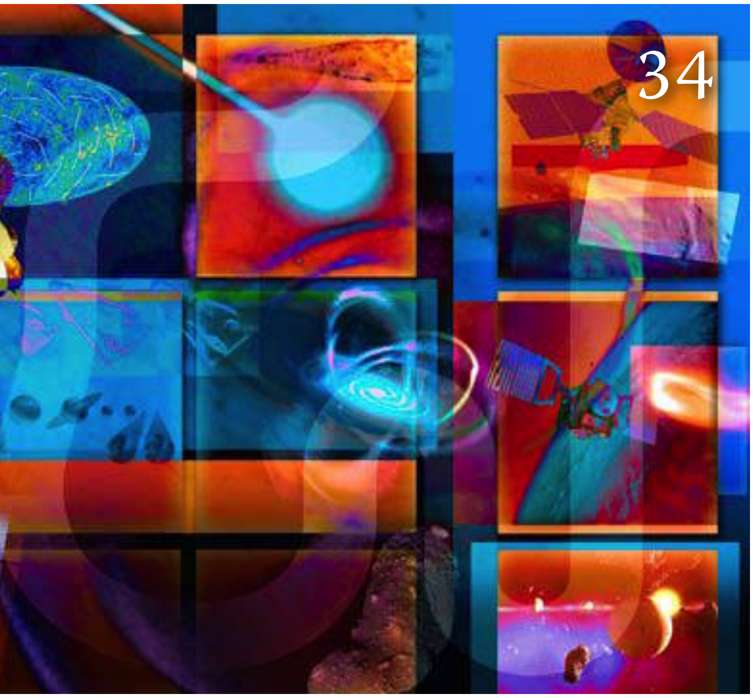
44 Hubble discovers 16 exotic planets

64 Portraits from Mars

84 Make Hubble shots your own dazzling photos

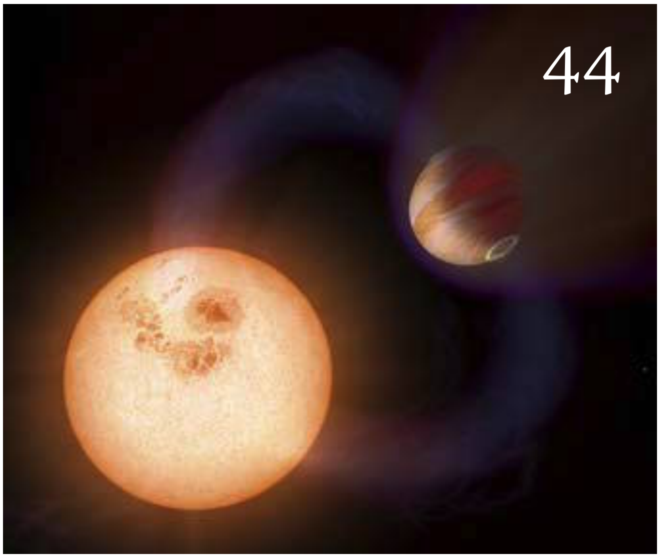
Astronomy
The world's best-selling astronomy magazine
VOL. 35, NO. 1

january 2007



34

ASTRONOMY: KELLIE JAEGER



44

NASA/ESA/A. SCHALLER (FOR STScI)

06 **This month in *Astronomy***
Astronomy's new award

08 **Beautiful universe**

12 **Letters**

16 **Bob Berman's strange universe**
Oddballs in the sky

18 **Glenn Chaple's observing basics**
Goddess of beauty

20 **Phil Harrington's binocular universe**
Cascading down the Giraffe's neck
ONLINE EXTRA: Explore the hidden gems of Camelopardalis.

24 **Astro news**
Astronomers find direct evidence of dark matter, and more

/// SPECIAL RETROSPECTIVE

34 **Top 10 astronomy stories of 2006**
Cosmologists peered into the Big Bang, astronomers tallied 200 alien worlds, and planetary scientists captured a comet. **FRANCIS REDDY**
ONLINE EXTRA: The year's top story may get a second shot at greatness.

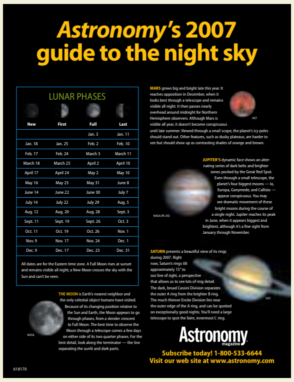
44 **Hubble discovers 16 exotic planets**
Egg-shaped planets with dazzling aurorae must be the norm for these new worlds that orbit within shouting distance of their parent stars. **RAY VILLARD**

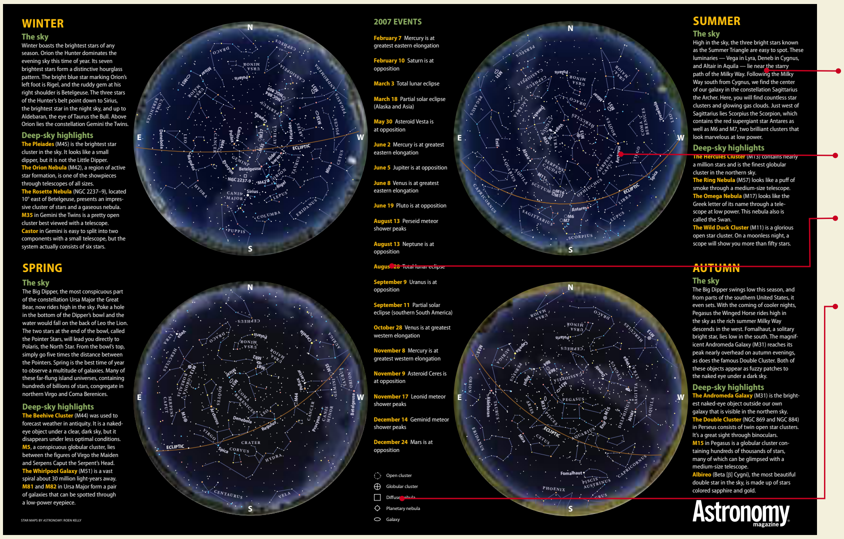
50 **Is the Orion Nebula as big as the Moon?**
The Moon's apparent size provides a yardstick for comparing the sky's best-known targets. **FRANCIS REDDY**

52 **The sky this month**
Return of the evening star
MARTIN RATCLIFFE AND ALISTER LING

BONUS PULLOUT!

Astronomy's sky guide will keep you looking up all year.


Astronomy's 2007 guide to the night sky
LUNAR PHASES
Astronomy
Subscribe today! 1-800-533-6644
Visit our web site at www.astronomy.com


WINTER
SPRING
2007 EVENTS
SUMMER
AUTUMN
Astronomy

Each season offers its own observing treats to explore

Star maps show you the entire sky

The calendar lists the year's must-see sky events

Find deep-sky objects easily with this map key

PLUS: Get Moon phases for 2007, planet rise and set times, and info on which planets to watch this year

64 **Portraits from Mars**

Images from Spirit and Opportunity turn raw science into artistic landscapes. **JIM BELL**

ONLINE EXTRA: See more beautiful images of the Red Planet.

70 **All about the Crab Nebula**

A supernova blast seen in 1054 continues to shed light on stellar evolution. **RAYMOND SHUBINSKI**

ONLINE EXTRA: Watch the Crab's central pulsar at work.

76 **Sun studio**

Learn how to capture dazzling solar photos. **GARY PALMER**

80 **Ask Astro**

Conservation laws and cosmic expansion, star birth, and occultations

84 **Make Hubble shots your own dazzling photos**

You can turn astronomical data into gorgeous images with the authors' *Photoshop* plug-in.

ROBERT L. HURT AND LARS LINDBERG CHRISTENSEN

ONLINE EXTRA: Get tips on managing your metadata.

89 **Advertiser index**

90 **Celestron's Onyx 80EDF**

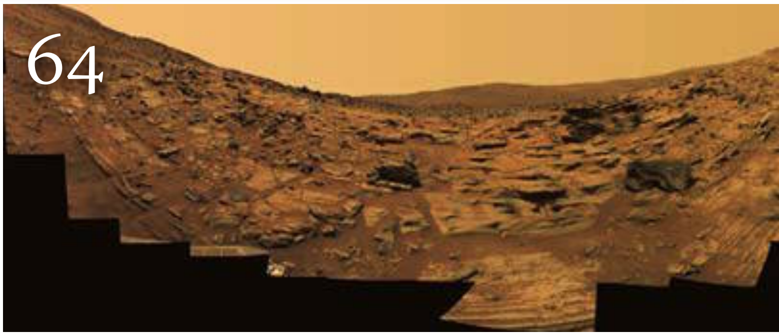
Don't let this scope's compact size fool you — it's a high-quality workhorse. **PHIL HARRINGTON**

92 **New products**

94 **Coming events**

101 **Reader gallery**

ONLINE EXTRA Visit **Astronomy.com/toc** for bonus material — it's free and exclusive to *Astronomy* magazine readers. Follow the instructions on page 12 to get access.



NASA/JPL-CALTECH/USGS/CORNELL

NASA/ESA/J. HESTER AND A. LOLL (ASU)

GEMINI OBSERVATORY/T. RECTOR (UAA)

{ THIS MONTH IN *ASTRONOMY* }

BY DAVID J. EICHER

Astronomy's new award

Congratulations to Celestial North, Inc., an astronomy club based in Freeland, Washington! Last September, Celestial North became the recipient of *Astronomy* magazine's first annual Out-of-this-World Award, which recognizes ongoing astronomy club outreach efforts.

The $2,500 prize rewards Celestial North's sustained efforts to involve the Puget Sound community in the science and hobby of astronomy. *Astronomy* magazine editors chose Celestial North from 32 clubs throughout the United States and Puerto Rico that submitted entries.

Celestial North's award-winning outreach includes:

- An astronomy radio news show, "It's over your head," on local public broadcasting station KSER 90.7 FM. In addition, Celestial North allows kids to participate on-air and in the production process.
- A partnership with the University of Washington's Project AstroBio program
- Space-science presentations at different grade levels in local schools in support of the state of Washington's Assessment of Student Learning
- Multimedia presentations at local public schools, the Table Mountain Star Party, and Seattle's Pacific Science Center

Celestial North will use the prize money toward enhancing and promoting its radio show and public presentations. The club believes the radio program, along with its archive, can function as a dynamic tool to help bring astronomy to the classroom.

Runners-up for the 2006 award are the Escambia Amateur Astronomers' Association (EAAA) in Pensacola, Florida, and the West Kentucky Amateur Astronomers of Golden Pond, Kentucky.

The Escambia Amateur Astronomers' Association brings astronomy to its community in a variety of ways. The club promotes astronomy through events with scout troops, schools, and at nearby Eglin Air Force Base. The EAAA also maintains an e-mail network to notify club members and local media of breaking space news.

The West Kentucky Amateur Astronomers conducts sidewalk programs with schools, libraries, scout troops, and parks. These events include summer sessions at the Kentucky Sheriffs' Boys and Girls Ranch — a camp for underprivileged children.

We are proud of Celestial North and all the clubs that entered the contest. Your tireless efforts and unwavering commitment sustain our beloved hobby. Indeed, today's public programs inspire tomorrow's astronomers and astronauts.

For a complete list of the 2006 entrants, visit www.astronomy.com/award.

If you are a member of an astronomy club, you can list your group's information in our online index at www.astronomy.com/groups. If your club hosts star parties or similar gatherings, you can also post the event information on our web site at www.astronomy.com/events.

David J. Eicher
Editor

Astronomy

Volume 35, Number 1

Editor David J. Eicher
Art Director LuAnn Williams Belter

EDITORIAL STAFF
Managing Editor Dick McNally
Senior Editors Michael E. Bakich, Richard Talcott
Associate Editors Laura Baird, Laura Layton, Francis Reddy
Assistant Editor Jeremy McGovern
Editorial Assistant Valerie Penton
Editorial Intern Katie Neubauer

ART STAFF
Graphic Designer Joel Marsh
Illustrators Theo Cobb, Rick Johnson, Roen Kelly
Production Coordinator Joni Hauser

CONTRIBUTING EDITORS
Bob Berman, Glenn F. Chaple, Jr., Stephen J. Edberg, Phil Harrington, David Healy, Ray Jayawardhana, Alister Ling, Steve Nadis, Tom Polakis, Martin Ratcliffe, Mike D. Reynolds, William Schomaker, John Shibley, Raymond Shubinski

EDITORIAL ADVISORY BOARD
Buzz Aldrin, Marcia Bartusiak, Timothy Ferris, Alex Filippenko, Adam Frank, John S. Gallagher III, William K. Hartmann, Paul Hodge, Anne L. Kinney, Edward Kolb, Stephen P. Maran, S. Alan Stern, James Trefil

[Kalmbach Publishing Co.]
President Gerald B. Boettcher
Vice President, Editorial, Publisher Kevin P. Keefe
Vice President, Advertising Scott Stollberg
Corporate Art Director Maureen M. Schimmel
Managing Art Director Michael Soliday
Production Manager Annette Wall
Corporate Circulation Director Michael Barbee
Single Copy Sales Director Jerry Burstein
Circulation Specialist Nicole Radomski
Circulation Coordinator Natalie Kranzman

ADVERTISING DEPARTMENT
(888) 558-1544
Advertising Sales Manager Howard Hoerl
hhoerl@astronomy.com
Advertising Sales Representative Ken Kozerski
kkozerski@astronomy.com
Ad Services Representative Katie Wendt
kwendt@kalmbach.com

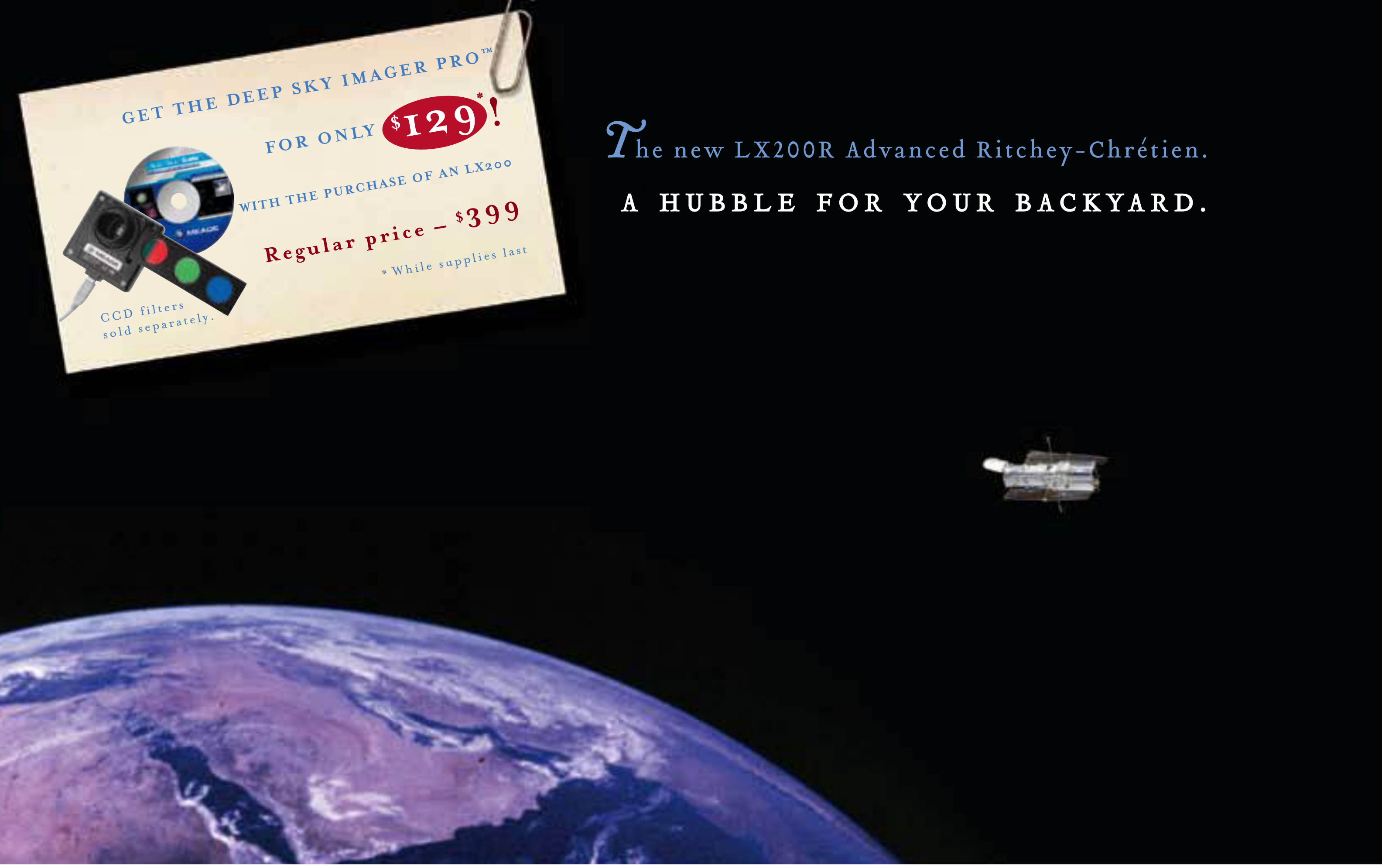
RETAIL TRADE ORDERS AND INQUIRIES
(800) 558-1544, ext. 818; outside the U.S. and Canada: (262) 796-8776, ext. 818

CUSTOMER SALES AND SERVICE
(800) 533-6644; fax: (262) 796-1615
customerservice@kalmbach.com

SPECIAL E-MAIL ADDRESSES
Ad Sales adsales@astronomy.com
Ask Astro askastro@astronomy.com
Books books@astronomy.com
Letters letters@astronomy.com
Products products@astronomy.com
Reader gallery readergallery@astronomy.com

The Audit Bureau

Editorial phone: (262) 796-8776; advertising: (888) 558-1544; customer service & sales: (800) 533-6644; outside the U.S. and Canada: (262) 796-8776, ext. 421, Monday through Friday, 8:30 A.M. to 5 P.M. CT, Fax: (262) 796-1615; E-mail: customerservice@kalmbach.com. Please include your name, mailing address, and telephone number with any correspondence. Copyright © 2006 Kalmbach Publishing Co., all rights reserved. Material in this publication may not be reproduced in any form without permission. Printed in the U.S.A. Allow 6 to 8 weeks for new subscriptions and address changes. Subscription rate: single copy: $5.95; 1 year $42.95, 2 years (24 issues) $79.95, 3 years (36 issues) $114.95; Canadian & foreign: 1 year $58, 2 years $110, 3 years $160. Payable in U.S. funds drawn on U.S. Banks. (Canadian price includes GST.) Expedited Delivery Service Surcharges: Domestic 1st Class $30 per year, Canadian air $30 per year, Foreign air, $60 per year. BN 12271 3209 RT. Not responsible for unsolicited materials.



GET THE DEEP SKY IMAGER PRO™
FOR ONLY $129*!
WITH THE PURCHASE OF AN LX200
Regular price – $399
* While supplies last

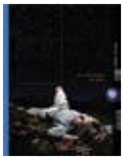
CCD filters
sold separately.

The new LX200R Advanced Ritchey-Chrétien.

A HUBBLE FOR YOUR BACKYARD.

ALL-NEW OPTICAL SYSTEM

LX200®R It's a story of evolution. Traditional Ritchey-Chrétiens (RCs) are reflectors that deliver a coma-free, flat field of view. RC optical designs (from a variety of manufacturers) are found in most of the world's top observatories and NASA's Hubble Space Telescope. But the hyperbolic mirrors in these telescopes are so expensive to manufacture, that they are out of reach for most amateur astronomers. That's why Meade engineers developed the radical new Advanced Ritchey-Chrétien (ARC) design. This Advanced RC design uses a hyperbolic secondary mirror with a corrector-lens-and-spherical-primary-combination that performs as one hyperbolic element. Advanced RC telescopes offer a coma-free, flat field of view that rivals traditional RC telescopes at a fraction of the cost. The design even eliminates diffraction spikes and improves astigmatism, both of which are inherent in the traditional RC design. When reviewing Meade's Advanced Ritchey-Chrétien, the RCX400, Sky and Telescope magazine said, "[It] does indeed perform like a Ritchey-Chrétien." The LX200R combines this revolutionary new optical system with the field-proven performance of the highly popular LX200--making Advanced RC performance available to everyone.



New **2007 Meade Catalog** is here!

Download or order the
150 page catalog at
meade.com/catalog

	8"	10"	12"	14"	16"
» Focal Ratio	F/10	F/10	F/10	F/10	F/10
» Price	$2,699	$3,699	$4,699	$6,499	$12,999
» UHTC™	INCLUDED	INCLUDED	INCLUDED	INCLUDED	INCLUDED
» OTA w/UHTC	$1,299	$1,799	$2,649	$3,699	$7,499

MEADE®

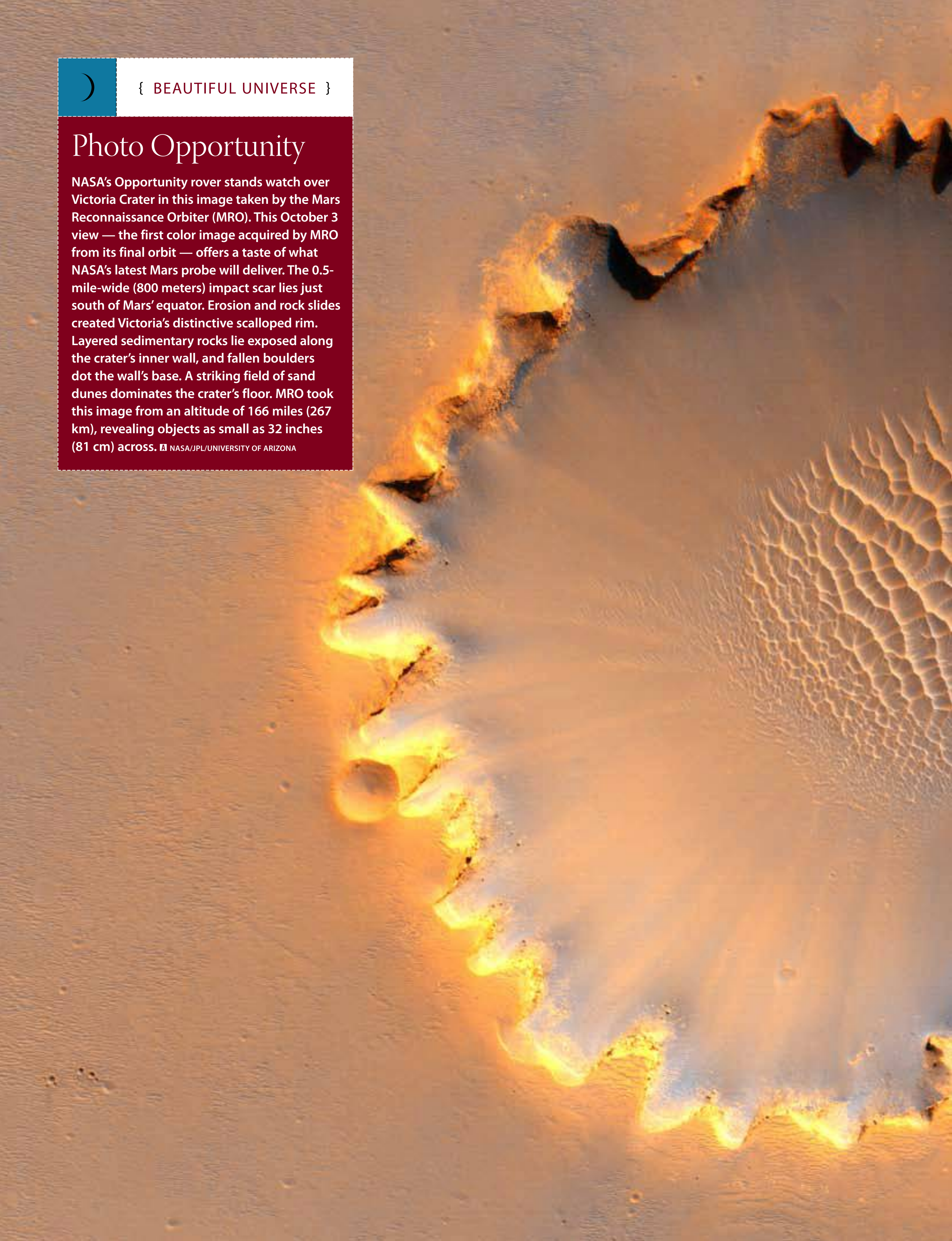
MEADE.COM | 800.919.4053

TELESCOPES.COM (800.958.6030) • ASTRONOMICS (800.356.6603) • B & H PHOTO (800.329.0315) • OPT CORP. (800.338.9638)
DURANGO SKIES (970.259.5400) • ADORAMA (800.223.2500) • SKIES UNLIMITED (888.947.2673) • CANADA – KHAN SCOPE (800.580.7160)

30-06138

{ BEAUTIFUL UNIVERSE }

Photo Opportunity



NASA's Opportunity rover stands watch over Victoria Crater in this image taken by the Mars Reconnaissance Orbiter (MRO). This October 3 view — the first color image acquired by MRO from its final orbit — offers a taste of what NASA's latest Mars probe will deliver. The 0.5-mile-wide (800 meters) impact scar lies just south of Mars' equator. Erosion and rock slides created Victoria's distinctive scalloped rim. Layered sedimentary rocks lie exposed along the crater's inner wall, and fallen boulders dot the wall's base. A striking field of sand dunes dominates the crater's floor. MRO took this image from an altitude of 166 miles (267 km), revealing objects as small as 32 inches (81 cm) across. NASA/JPL/UNIVERSITY OF ARIZONA

Opportunity

Meade® and *Astronomy®* magazine bring you the

2006 Winter Sweepstakes

ENTER TO WIN

one of these great prizes!

Hurry!

Entries must
be postmarked by
January 7, 2007

To enter, fill out and mail the attached card today!

Or save a stamp and enter online at
www.astronomy.com

Grand Prize

Grand Prize: 12-inch Meade LX90™ GPS (One winner)

Imagine owning a legendary Meade Schmidt-Cassegrain Telescope for free. Amazingly precise go-to accuracy and superior optics have long made the LX90 a favorite of astrophotographers and observers alike. Now with added features like GPS and AutoAlign™, which make alignment a breeze, the LX90 GPS is a grand prize indeed. Includes: Ultra-High Transmission Coatings, AutoStar® controller with its 30,000-object database, red-dot viewfinder and an 8x50 optical viewfinder, Periodic Error Correction, LX200™ series adjustable tripod, and more.
Prize value: $3,294

MEADE
LX90GPS

IMAGE COURTESY OF JASON WARE. PHOTOGRAPHED WITH A MEADE MODEL 152ED 6-INCH APOCHROMATIC REFRACTOR.

MEADE®

Astronomy® magazine

CIR-ADH-06X1101RH

First Prize: 8-inch Meade LXD75™ SN (One winner)

For spectacular wide-field images of the deep sky, it's hard to beat the large aperture, fast f/4 optical system, and rock-solid German Equatorial mount of the 8-inch LXD75 Schmidt Newtonian. Win the LXD75 and you'll get an instrument already prized for its exquisite smoothness, stability, and razor-sharp optics. Includes: Ultra-High Transmission Coatings, AutoStar® controller with its 30,000-object database, 8x50 optical viewfinder, adjustable field tripod, and more. **Prize value: $1,124**

Second Prize: Meade ETX®- 90 PE (One winner)

Win the one that started it all. The telescope that revolutionized amateur astronomy is now better than ever. Its go-to capability is virtually plug-and-play. The ETX90 is the ultimate dream scope if you're just starting out in astronomy and the perfect ultra-portable for the seasoned veteran. Includes: Ultra-High Transmission Coatings, AutoStar® controller with its 30,000-object database, red-dot viewfinder, sturdy field tripod, and more. **Prize value: $749**

Third Prize: Series 5000™ 80mm ED Refractor (One winner)

For crisp wide-field observing and imaging, nothing beats a true triple-element ED apochromatic refractor (APO). This is especially true in astrophotography, where APOs have produced some of the most beautiful images of the heavens ever taken from Earth. With Meade's new Series 5000 80mm ED Refractor, expert observers will be delighted by the total absence of color fringing and the scope's textbook-perfect pinpoint star images. Prize includes a Series 5000 two-inch diagonal and carry case. **Prize value: $699**

Fourth Prize: Meade Deep Sky Imager™ II (One winner)

Take amazing deep-sky photographs of galaxies, nebulae, star clusters and planets with the new Deep Sky Imager II. By combining a high-performance CCD camera with software that takes the difficulty out of this exciting hobby, the Deep Sky Imager makes CCD imaging fun for everyone. It combines ease-of-use with a larger chip, greater sensitivity, higher resolution, and dramatically lower thermal noise. Meade engineers have invented a remarkable new way to reduce noise without a cooler. This means you can take exposures for hours at a time. And the new thermal monitoring sensors automatically match your dark frames to ambient temperature so it's nearly impossible to take an uncalibrated picture. The DSI II is the world's first uncooled camera with low thermal noise. And that's as cool as it gets.

Prize value: $699

IMAGE COURTESY OF MARK SIBOLE.
PHOTOGRAPHED WITH A "DEEP SKY IMAGER PRO" AND A 10-INCH LX200.

Astronomy's Winter 2006 Sweepstakes

Official Rules

No Purchase Necessary. The official start date for the *Astronomy* Winter 2006 Sweepstakes is September 24, 2006. Official entry forms are bound in the November 2006, December 2006 and January 2007 issues of *Astronomy*. The *Astronomy* Winter 2006 Sweepstakes is open to residents of the United States and Canada (except Quebec) only, 18 years of age or older. Employees (and their dependents and immediate household members) of Kalmbach Publishing Co., Kalmbach's advertising and promotional agencies, and participating sponsors are not eligible to participate.

Sweepstakes Entry. To enter, complete and mail the official entry form or a postcard with name, address, city, state or province, zip and telephone number on a postcard and send it to: *Astronomy* Winter 2006 Sweepstakes, P.O. Box 378, Waukesha, WI 53187-0378. Or enter online at www.astronomy.com by filling in the Online Entry form and hitting the SEND key. The Online Entry form must be filled out completely to be eligible. Incomplete or defaced entry forms are void. One entry per household. The official ending date for the *Astronomy* Winter 2006 Sweepstakes is January 7, 2007, and all entries must be transmitted or postmarked no later than that date.

Prizes and Odds of Winning. One drawing will be held on or about January 31, 2007, for the following awards: One Grand Prize consisting of a 12-inch Meade LX90 GPS™ (retail value $3294). One First Prize consisting of an 8-inch Meade LXD75™ SN (retail value $1124). One Second Prize consisting of a Meade ETX®-90 PE (retail value $749). One Third Prize consisting of a Meade Series 5000™ 80mm ED Refractor (retail value $699). One Fourth Prize consisting of a Meade Deep Sky Imager™ II (retail value $699). Cash equivalents of merchandise will not be awarded. Substituting prizes is not allowed. Any applicable federal, state and/or local taxes are the responsibility of the winner. Odds of winning depend on the number of entries received. Total circulation for *Astronomy* magazine is 129,620. Sweepstakes void in Quebec and void where prohibited.

Validation and Acceptance. Winners in the *Astronomy* Winter 2006 Sweepstakes will be selected in a random drawing conducted by an independent judging organization whose decisions are final. Canadian prize awards subject to skill test requirement. By entering the sweepstakes, participants agree to be bound by these official rules and all decisions of the judging organization. Sweepstakes entries void if not legible, not completed in full, not obtained legitimately, or if forged, photocopied, mechanically reproduced, late or tampered with. The potential winners must sign and return an Affidavit of Eligibility, publicity release and Release of Liability within fourteen (14) days of notification. In the event of noncompliance, alternate winners will be randomly drawn. No responsibility is assumed for lost, stolen, misdirected or late entries or notifications. All sweepstakes entries become the property of the sponsor and will not be returned.

Winner's List. For a list of winners, send a stamped, self-addressed envelope to: *Astronomy* Winter 2006 Sweepstakes Winners List, P.O. Box 1612, Waukesha, WI 53187-1612. Residents of FL, VT and WA may omit stamp. Requests must be received by March 30, 2007. Or check the *Astronomy* Web site (www.astronomy.com) after April 24, 2007.

Kalmbach Publishing Co. shall not be liable for any injury, loss, damage, cost or expense arising directly or indirectly, in connection with the sweepstakes and the prize awarded.

Sponsored by Kalmbach Publishing Co., P.O. Box 1612, Waukesha, WI 53187-1612.

Readers sound off about Pluto's demise

Pluto, considered a planet for so long — despite bigger objects being discovered — should be grandfathered in as a planet. Did we forget the name refers to the god of the underworld, which is far away? And the first two letters of "Pluto," are Percival Lowell's initials. The announcement of Pluto's discovery was actually delayed to coincide with Lowell's birthday.

From now on, scientists can call any new object they find anything they please. But for the rest of us, Pluto the planet is just fine. — **NORM GUARNI,** WARRINGTON, ALABAMA

I valued Francis Reddy's swift reporting on Astronomy.com about the planet-definition brouhaha — although I'm shocked at the results.

To be more concerned with the status of the classical planets than with what nature reveals is retrograde thinking that smacks more of Galilean heresy-hunting than true science. — **GEORGE STACEY,** CALGARY, ALBERTA

And the winner is...

Astronomy.com asked readers to submit ideas for a new solar system mnemonic. The traditional memory-aid device "My Very Educated Mother Just Served Us Nine Pizzas" doesn't work without Pluto.

We received 645 contest entries, and the *Astronomy* staff selected Kyle Sullivan of Lumberton, Mississippi, as the grand-prize winner of Celestron SkyMaster 25x100 binoculars. His winning sentence: **My Violent Evil Monster Just Scared Us Nuts.** Kids should have no problem learning this one. As for adults, we'll just have to get used to it.

— ***ASTRONOMY* EDITORS**

Francis Reddy's "Pluto gets the boot!" (December 2006) explains how the International Astronomical Union (IAU) developed its planet definition. This story's online extra at Astronomy.com compiles all of Astronomy's *reporting on Pluto in one spot.*

What is a planet? It seems to me astronomers looking for planets in the universe will now have a problem convincing people they have actually found one. Dwarf-schwarf nit-picking. Just leave things alone.
— **DANNY SHOWALTER,** FAIR OAKS, CALIFORNIA

Regarding the definition of a planet, didn't somebody miss something? If Pluto was demoted because it hasn't cleared the neighborhood around its orbit, then isn't Neptune in the same boat? After all Neptune didn't "clear" Pluto. Perhaps Neptune should be a dwarf planet, too. — **DEAN DELGADO,** SANTA ANA, CALIFORNIA

Visit Astronomy.com/forums to read more opinions on Pluto's fate or post your own thoughts.

Corrections

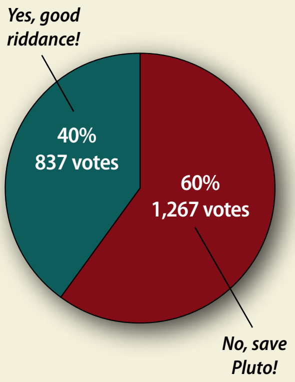
In Geoffrey W. Marcy's "The new search for distant planets" (October 2006), the graph on page 33 attributes "Velocity" to the exoplanet orbiting Gliese 876. The velocity, in fact, is the star's radial velocity as it wobbles toward and away from us.

In Steve Gottlieb's "How to observe exploding stars" (September 2006), the declination of the Pencil Nebula (Vela supernova remnant) given on page 66 should be –45°57'.
— ***ASTRONOMY* EDITORS**

We welcome your comments. Send letters to Astronomy Letters, *P. O. Box 1612, Waukesha, WI 53187; e-mail to letters@astronomy.com. Please include your name, city, state, and country. Letters may be edited for space and clarity.*

Online poll results

POLL QUESTION:
Do you think the IAU should omit Pluto as a planet?



Total votes: 2,104

Join the fun! Each week, Astronomy.com posts a poll question for visitors to answer. You can find the question on the lower right side of the home page.

Get more from Astronomy.com

Astronomy magazine readers have access to free, premium online content at Astronomy.com.

You must have an Astronomy.com account to view this content.

To create an account, go to www.astronomy.com/register.

Subscribers: Click "Create Magazine Subscriber Account" and enter the customer number on your subscription label. You'll enjoy unlimited access to the web site for the life of your subscription.

Newsstand buyers: Click "Create Newsstand Buyer Account" and enter this month's access code:
UK7S1A

If you've previously registered as a newsstand buyer, log in, click "My Account," and enter the code above.

You'll enjoy unlimited web-site access through the last day of the month listed on the cover.

ONLINE CONTENT

Astronomy.com's exclusive **podcasts** give you the latest news, interviews, and sky info. You can listen directly on your computer or download them to your MP3 player for later.

DSI
$299

THE PERFECT STOCKING STUFFER

DEEP SKY IMAGER™

Autostar Suite
MEADE

$299

If you've been around telescopes for more than ten minutes, you understand the limitations of the human eye to detect color and detail in very faint objects like nebulae, galaxies and star clusters. The key to unlocking the visual wonders of the universe in all their grandeur is astrophotography. Until recently, photographing the night sky was reserved for professionals and a few patient amateurs. But no more. The user-friendly and affordable DSI imager has brought the joys of astrophotography to all. *Sky & Telescope* magazine wrote, "I came away from my DSI experience wondering why anyone with a telescope and computer wouldn't want to own one of these cameras."

All images were taken
with Meade telescopes
and Deep Sky Imager.

NGC3628 – Edge-on Spiral Galaxy

Chuck Domaracki

M20 – The Trifid Nebula

John Hoot

M64 – The Black Eye Galaxy

George Lilley

M27 – The Dumbell Nebula

John Hoot

Omega Centauri - Star Cluster

Jean-Paul Longchamp

RECOMMENDED DSI ACCESSORIES

MEADE SERIES 4000™ FOCAL REDUCERS

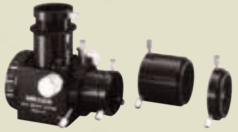
f/6.3 Focal Reducer
$129.95

f/3.3 Focal Reducer
$149.95

MEADE DSI FAN

$49.00

MEADE #644 FLIP-MIRROR



CCD Photo-Visual System **$149.95**

MEADE.COM 800-919-4053

MEADE®

Telescopes.com	Astronomics	B & H Photo	OPT Corp.	Durango Skies	Adorama	Skies Unlimited	CANADA Khan Scope
800-958-6035	800-356-6603	800-329-0315	800-338-9638	970-259-5400	800-223-2500	888-947-2673	800-580-7160

U.S. and Int'l patents pending. 30-06152.

GET THE DEEP SKY IMAGER PRO™

FOR ONLY $129*!

WITH THE PURCHASE OF AN LX90

Regular price – $399

* While supplies last

CCD filters sold separately.

24 ORBITING REASONS

the new LX90GPS can locate over 30,000 objects including itself.

New **2007 Meade Catalog** is here!

Download or order the 150 page catalog at **meade.com/catalog**

Patents: 6,304,376; 6,392,799; 6,563,636; D422,610; and other patents pending. 30-06093.

	8"	10"	12"
FOCAL RATIO	F/10	F/10	F/10
PRICE	$1999	$2699	$3299
UHTC™	INCLUDED	INCLUDED	INCLUDED

- Schmidt-Cassegrain optical design
- Diffraction-limited optics
- AutoAlign™
- AutoStar® telescope controller
- Sony® GPS sensor
- Oversized primary mirror
- SmartDrive™ (Periodic Error Correction)
- 7°/sec Slew/GoTo speed
- Rigid double-tine fork mount
- LX200-series sturdy field tripod
- Red-dot finder & 8x50 optical finder
- AutoStar Suite™ AE

The NEW LX90GPS™ can do more than track satellites. It can communicate with them as well. Turn it on and the built-in Sony® GPS sensor immediately determines your precise date, time and location. Meade's patented Auto-Align™ then uses this info to align your scope for a tour of the most spectacular sights in the universe. With all the features of the legendary LX90 Schmidt-Cassegrain plus the ability to communicate with satellites, the new LX90GPS now has it all. When it comes to industry-leading American-made optics, depth of features, and value for your dollar, the LX90GPS is the best Schmidt-Cassegrain telescope you can find that can find itself.

MEADE®

MEADE.COM | 800.919.4053

TELESCOPES.COM (800.958.6030) • ASTRONOMICS (800.356.6603) • B & H PHOTO (800.329.0315) • OPT CORP. (800.338.9638)
DURANGO SKIES (970.259.5400) • ADORAMA (800.223.2500) • SKIES UNLIMITED (888.947.2673) • CANADA – KHAN SCOPE (800.580.7160)

30-06136

MEADE®

PREMIUM ACCESSORIES

www.meade.com/accessories or call 800-919-4053

Ultra Wide Angle Series 5000™

82° AFOV

Focal Length	Barrel Size	AFOV	Price
4.7	1.25"	82°	$199
6.7	1.25"	82°	$199
8.8	1.25"	82°	$199
14	1.25"	82°	$199
18	1.25"	82°	$279
24	2.00"	82°	$399
30	2.00"	82°	$449

Ultra Wide Angle Set **$749**

Includes: 6.7, 18, 30mm and aluminum case

Super Wide Angle Series 5000™

68° AFOV

Focal Length	Barrel Size	AFOV	Price
16	1.25"	68°	$179
20	1.25"	68°	$199
24	1.25"	68°	$249
28	2.00"	68°	$279
34	2.00"	68°	$299
40	2.00"	68°	$399

Super Wide Angle Set **$599**

Includes: 16, 24, 34mm and aluminum case

5 Element Plössl Series 5000™

60° AFOV

Focal Length	Barrel Size	AFOV	Price
5.5	1.25"	60°	$89
9	1.25"	60°	$89
14	1.25"	60°	$89
20	1.25"	60°	$89
26	1.25"	60°	$99
32	2.00"	60°	$149
40	2.00"	60°	$199

5 Element Plössl Set **$349**

Includes: 5.5, 14, 20, 32mm and aluminum case

TeleXtenders Series 5000™

Magnification	Barrel Size	Price
2x	1.25"	$159
3x	1.25"	$159
5x	1.25"	$159
2x	2.00"	$229

2" Enhanced Diagonal Series 5000™

NEW

- Enhanced dielectric coatings with 99% reflectivity over the visual spectrum
- Interferometer tested
- Thermally stable Pyrex® glass
- Includes 1.25" eyepiece adapter with non-marring compression ring

$199.00

QX Wide Angle Eyepieces Series 4000™

70° AFOV

Focal Length	Barrel Size	AFOV	Price
15mm	1.25"	70°	$79
20mm	1.25"	70°	$79
26mm	2.0"	70°	$89
30mm	2.0"	70°	$89
36mm	2.0"	70°	$99

Eyepiece & Filter Set Series 4000™

NEW

MEADE Series 4000

Designed and manufactured to exacting standards. Series 4000 Super Plössl eyepieces deliver 52° AFOV (44° for the SP40mm) with all of the resolution, edge-of-field sharpness and color correction demanded in the most advanced visual applications.

~~$299~~

Only $199 if purchased together with any Meade telescope.

Each Series 4000 Set Includes:

6.4mm Super Plössl	$49.00
9.7mm Super Plössl	$49.00
12.4mm Super Plössl	$49.00
15mm Super Plössl	$49.00
32mm Super Plössl	$69.00
40mm Super Plössl	$69.00
2x Barlow Lens (#126)	$47.95
Color Filter Set #1 (yellow/red/green/blue)	$49.95
Moon Filter	$16.95
Aluminum Hard Carry Case	$69.95
Total price if purchased separately	**$518**

Deep Sky Imager™ with AutoStar Suite™

DSI

DSI Pro

DSI (Color)	$299
DSI Pro (Monochrome)	$399
DSI Pro with filters	$499
DSI II (Color)	$599
DSI II Pro (Monochrome)	$599
DSI II Pro with filters	$699

more info at meade.com/dsi

Lunar Planetary Imager (LPI™)

Now $99

The LPI™ camera will have you taking pictures of the moon and planets like a pro – right out of the box with exclusive features like Meade's Drizzle Technology™.

more info at meade.com/lpi

AC Adapters

- **RCX400™ AC Adapter** **$79.95**
  For RCX400, LX200™GPS, LX200R™, LX90™, LX90GPS™, LXD55, LXD75 telescopes
- **#541 AC adapter** **$49.95**
  For LX90GPS, LX90, LX10, EXT®90, EXT105, EXT125 telescopes
- **#546 AC adapter** **$19.95**
  For EXT®60, EXT70, EXT80, DS-2000, NG series telescopes
- **#607 cigarette lighter adapter** **$25.00**
  For all Meade telescopes

Focal Reducers Series 4000™

$129.95

f/6.3 Focal Reducer *
- 4-element, multi-coated
- Reduces exposure times by approximately 50%

$149.95

f/3.3 CCD Focal Reducer *
- 3-element, multi-coated
- Variable T-adapter included

* For photographic use only

Wireless AutoStar® II

Now $199

Remote control of your telescope has never offered such freedom. Just plug the Wireless AutoStar II into the handbox port of your LX200GPS, LX200R, or RCX400 telescope and wireless control of the universe is at your fingertips.

* Only for use on LX200GPS, LX200R and RCX400 telescopes.

MEADE AUTHORIZED DEALERS

TELESCOPES.COM
800-958-6030

ASTRONOMICS
800-356-6603

B & H PHOTO
800-329-0315

OPT CORP.
800-338-9638

DURANGO SKIES
970-259-5400

ADORAMA
800-223-2500

SKIES UNLIMITED
888-947-2673

CANADA
KHAN SCOPE
800-580-7160

Ultra-Wedge

- Heavy-duty construction
- Ultra-smooth, fine tune adjustments
- High-precision polar alignment
- Rock solid

$499.95

* For LX90, LX200, and RCX400 series telescopes.

Copyright © 2006 Meade Instruments Corporation. Patents Pending. All rights reserved. 30-06139.

{ BOB BERMAN'S STRANGE UNIVERSE }

BY BOB BERMAN

Oddballs in the sky

Do you have any normal friends?

I sure don't. And that's just fine. Normal people aren't as much fun as the unusual ones. Maybe it's the same way with the sky. As the clock strikes midnight on New Year's, Sirius will dutifully blaze at its highest point of the night, just as it has for centuries. But after that, things go bananas. The sky's brightest denizens will all be wonderfully odd in 2007.

The fun starts with the very first Full Moon, the night of January 2/3. This will be the highest Full Moon until 2024! It'll hover straight up at midnight over south Florida and south Texas.

That's odder than you might think: The Moon normally avoids the zenith like the plague. (The Sun is never straight up from any part of the continental United States, Canada, or Europe.)

This happens because the Moon's orbit now tilts the same way Earth is slanted. This temporary state of affairs will produce several days of weirdly high and low Moons each month throughout 2007, even after that first Full Moon. And that's just the beginning. Several astro-cycles are now coming together like a class reunion. The Sun reaches an extreme, too. We're at sunspot minimum, and the night sky will probably respond by assuming its darkest guise of the decade. The space between the stars now grows unusually murky, as if someone has turned the brightness knob all the way down. Explanation: Airglow, the greatest natural influence on the background sky, varies with the sunspot cycle.

Venus is extreme, too. This month, it slowly emerges from the Sun's glare at dusk, raising the curtain on a display we haven't seen since 1999. That cloud-covered planet's behavior gets precisely duplicated every 8 years. Count back: In 1975, 1983, 1991, and 1999, the evening star was extraordinarily high and conspicuous. This happens when Venus reaches the eastern edge of its orbit just as that orbit angles most vertically from our horizon. But never mind the mechanical details. What matters are the results: It's now 8 years after the great 1999 apparition, so here we go again.

Watch Venus blaze high at dusk late this winter and especially in spring, when it won't even set until midnight or so. In May, it'll hover straight up for observers in South Florida's gatored communities. A zenithal Venus! How bizarre! This happens at 4 P.M., with the planet's dazzling –4 magnitude making it visible against the afternoon sky.

> WILL THIS PECULIAR alignment cause Wi-Fi spam from M20 to beam into our home computers?

If your backyard doesn't have alligators or lizards, neither January's midnight Full Moon, nor springtime's afternoon Venus will reach perfectly straight up, but they'll still be oddly high and anything but normal.

We're not finished with 2007's uniqueness. Consider the Moon's separation from us. On November 9, its oval orbit will carry it far into the distance, to a whopping 252,700 miles (406,700 kilometers) away. This will be the farthest, smallest Moon until the year 2020.

The three brightest sky-denizens, the Sun, Moon, and Venus, each do unusual things, but let's add number four — Jupiter, which also emerges from the Sun's glare in December. By month's end, early risers can check out Red Spot, Jr., the planet's oddest event since Voyager 1 passed by in 1979 carrying Chuck Berry music on a laserdisc.

Then, for a day starting on 2007's winter solstice, Earth, the Sun, Jupiter, and the Trifid Nebula (M20) all form a straight line. The meeting happens at the lowest point of the zodiac. Will this peculiar alignment cause Wi-Fi spam from M20 to beam into our home computers? Expect a paranoid web site to raise fears about this lineup.

As for our own planet, no need to hunt for strangeness — it's as close as your breath. Last summer, Hawaii's Mauna Loa reported the newest carbon-dioxide figures, and our planet's air now contains 381 parts per million (ppm). That's the largest increase ever, a rise of 2.6 ppm from last year. CO_2 is up 40 percent from 1848, up 100 ppm from the 280 ppm level it's held for the last 650,000 years. Whatever global consequences must follow, the CO_2 levels are not in dispute. So far as we know, no other planet is experiencing such a rapidly changing atmosphere.

More 2007 astro-oddities: We'll have the final March 21 equinox of our lives, reckoned by Universal Time (UT). In fact, all four equinoxes and solstices will happen so late this year that none of them will be matched or preceded until the 22nd century! Better not be in a hurry for summer to start.

Our planet also hits its far point from the Sun, aphelion, at its latest of the century, on the final hour UT of July 7. A more common date would have been July 4. Yet, strangely, the solar near point occurs at a normal January 3.

Eccentrics of the world, drink a New Year's toast under the sky. We're heading into an odd and special year.

Tele Vue®
Eyepieces in
Your Scope
Make
Star Charts
Come Alive!
IC 1318
γ
M29
CYGNUS
ε
NGC 6894
Veil Nebula
NGC 6940
22 Nagler

Nagler™ 82°
2.5mm to 31mm
"Tops in the field"

Panoptic™ 68°
15mm to 41mm
"Tack Sharp" favorite

Radian™ 60°
3mm to 18mm
20mm long eye-relief

Plössl 50°
8mm to 55mm
"Top Rated"

Veil image courtesy of Robert Gendler.
Illustration courtesy of Roen Kelly.

Available at:

Adorama
800.223.2500

Anacortes Telescope
800.850.2001

Astronomics
800.422.7876

Oceanside Photo
800.483.6287

Telescope.com
800.303.5873

Woodland Hills Telescopes
888.427.8766

Tele Vue eyepieces deliver fields of view so naturally wide, sharp and with such high contrast, the effect has been described with one word, "Spacewalk." As the leader in eyepiece technology for over 25 years, Tele Vue continuously pushes performance boundaries using the latest materials and optical coating techniques. From design stage to final quality control inspection of every eyepiece, the details are scrutinized. Your purchase is backed with the reassurance of technically accurate personal advice just a phone call away, a 5-year product warranty, and repair service should it be necessary. Whatever telescope you use, Tele Vue eyepieces extract the best possible images from it, so you can enjoy a visual experience "even better than you imagined."

Tele Vue Optics, Inc., 32 Elkay Drive, Chester, New York 10918 845.469.4551 **www.TeleVue.com**

TeleVue®
Visionary

BY GLENN CHAPLE

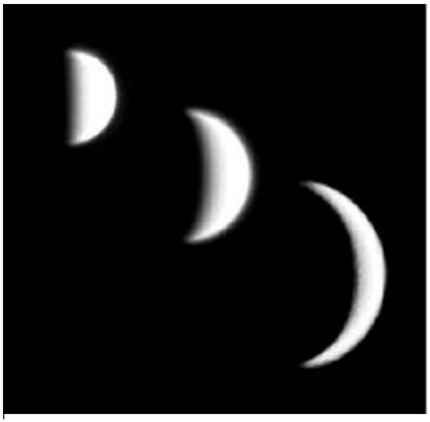
Goddess of beauty

Last month, I challenged you to identify the body in this image. If you guessed the photo depicts the Moon, you're wrong! While our satellite exhibits phases, the difference in size is not nearly as dramatic as this view. Note that the disk is uniformly white, lacking our Moon's dark maria, or "seas." This mystery object is our planetary neighbor Venus.

Galileo discovered the phases of Venus while studying this planet with the newly invented telescope in the early 1600s. To him, the phases were proof that Venus circles the Sun — instead of Earth, as was the prevalent belief in his time. The first half of 2007 provides an excellent opportunity to repeat Galileo's historic observations.

As the new year begins, Venus is nowhere to be seen, having reached superior conjunction on the far side of the Sun in late October. "First light" will occur near mid-January, when Venus emerges from the Sun's glare, making its entrance as a brilliant point of light low in the southwest sky just after sunset. A telescope magnifying just 50x will transform this sparkling gem into a white, featureless, gibbous "Moon." Higher powers won't improve the view because of the air turbulence prevalent so close to the horizon. No wonder astronomers prefer to study sky objects overhead!

From January until early June, Venus will climb higher and higher above the western horizon. If you make weekly telescopic observations, you'll see Venus grow in apparent size but the percentage of its illuminated surface decrease. The latter phase coincides with greatest eastern elongation from the Sun in early June. After that, things rapidly happen, as Venus begins to swing between the Sun and Earth and plummets toward the western horizon. Its disk will continue to grow while its phase diminishes to a thin crescent. Venus will disappear from view in August, with inferior conjunction, when Venus lies between Earth and the Sun, occurring on the 18th.



THESE PHASES occurred April 19, April 25, and May 15, 2004, from top to bottom, prior to Venus' inferior conjunction. JOHN RUMMEL

We can visualize Venus' changing face, or demonstrate it to others, by moving a ball (Venus) around a lightbulb (the Sun). When the ball is on the far side of the bulb, its illuminated side faces us, and we see the full phase. As the ball moves toward the left side of the bulb (the way Venus orbits the Sun), it appears to grow in size, but shrink in phase, as it takes on a "half-Moon" appearance. Continuing to a position nearly between the bulb and us, the ball becomes a large crescent.

Although its changing phases are interesting to watch, Venus isn't a particularly inspirational telescopic sight. With the exception of a handful of skilled observers who study Venus' clouds through filters, most of us settle for a glimpse of a pure-white, featureless disk. I find Venus is most visually appealing when viewed with the unaided eye — a dazzling spectacle outshone only by the Sun and Moon. It's easy to see why the ancients revered Venus as the goddess of beauty! The sky scene becomes even more stunning when the planet is paired with a crescent Moon — a sight my mother called the "stairway to the stars." An especially dramatic "stairway" will greet our eyes when the crescent Moon passes near Venus the evening of May 19.

There was a time not so long ago when astronomers envisioned Venus as a planet similar to ours in more than just size. While it's true Venus orbits the Sun some 25 million miles (40 million kilometers) closer than Earth, it was thought the dense cloud cover, possibly consisting of water vapor, reflected away much of the Sun's heat and light. Some science-fiction writers portrayed Venus as a warm tropical world teeming with life. Beginning in the 1960s, space probes from the Soviet Union and the United States put that fantasy to rest.

We now know the atmosphere — composed mostly of carbon dioxide — acts as a greenhouse, letting in small quantities of sunlight. The sunlight, when absorbed on the surface and converted to heat, becomes trapped. The surface temperature on Venus is a scorching 850° Fahrenheit (450° Celsius) — even hotter than Mercury's surface! The air pressure at the surface is more than 90 times what we experience at sea level on Earth. That's equal to the crushing pressure exerted by the ocean a half-mile down. It gets worse! The clouds, far from being just water vapor, are largely sulfuric-acid droplets. This goddess has a dark side, indeed.

Questions, comments, or suggestions? E-mail me at gchaple@hotmail.com.

Check out my observing-basics debut on *Astronomy*'s podcasts. You can listen to it January 5 at www.astronomy.com/basics.

Next month: We examine some heavenly motions. Clear skies!

Could String Theory Be the Long-Sought "Theory of Everything"?

Explore one of today's most thrilling ideas in modern physics with a video lecture series for nonscientists

One of the most exciting scientific adventures of all time is the search for the ultimate nature of physical reality, a hunt that in the last century has yielded such breakthroughs as Einstein's theory of relativity and quantum mechanics, two theories that radically altered our picture of space, time, gravity, and the fundamental building blocks of matter.

The latest advance in this epic quest is string theory—known as superstring or M-theory in its most recent versions. Based on the concept that all matter is composed of inconceivably tiny filaments of vibrating energy, string theory has potentially staggering implications for our understanding of the universe.

Wouldn't you love to understand string theory at a deeper level than is available from popular articles or even book-length treatments? Aren't you eager to look over the shoulder of a prominent string theorist at work—one who has a gift for explaining the subject to nonscientists and who has created computer-generated images to help make the concepts clear?

The Teaching Company offers just such a guide in Professor S. James Gates, Jr., director of the Center for String and Particle Theory at the University of Maryland. Dr. Gates has presented nearly 100 public talks on string theory.

The 24 lectures in **Superstring Theory: The DNA of Reality** incorporate Dr. Gates's matchless set of graphics, which introduce you to such concepts as hidden dimensions, dark matter, sizzling black holes, and a theory-destroying monster called the tachyon.

Spaghetti Strands

The essence of string theory is that the smallest, most fundamental objects in the universe are not little balls, knocking around like billiards, as had been thought for about 2,000 years. Instead, these small objects are super-microscopic filaments—like tiny strands of spaghetti—whose different vibrational modes produce the multitude of particles that are observed in the laboratory.

One of the most celebrated features of the string approach is that it predicts more dimensions than the three of our familiar spatial world plus one of time.

About Our Sale Price Policy

Why is the sale price for this course so much lower than its standard price? Every course we make goes on sale at least once a year. Producing large quantities of only the sale courses keeps costs down and allows us to pass the savings on to you. This approach also enables us to fill your order immediately: 99% of all orders placed by 2:00 p.m. eastern time ship that same day. Order before February 13, 2007, to receive these savings.

About The Teaching Company

We review hundreds of top-rated professors from America's best colleges and universities each year. Fewer than 10% of these world-class scholar-teachers are selected to make The Great Courses. We've been doing this since 1990, producing more than 2,000 hours of material in modern and ancient history, philosophy, literature, fine arts, the sciences, and mathematics for intelligent, engaged, adult lifelong learners. If a course is ever less than completely satisfying, you may exchange it for another or we will refund your money promptly.

Lecture Titles

1. The Macro/Micro/Mathematical Connection
2. Who Is Afraid of Music?
3. Apropos Einstein's Perfect Brainstorm Year
4. Honey, I Shrunk to the Quantum World—Part I
5. Honey, I Shrunk to the Quantum World—Part II
6. Dr. Hawking's Dilemma
7. I'd Like to See a Cosmos Sing in Perfect Harmony
8. Einstein's Hypotenuse and Strings—Part I
9. Einstein's Hypotenuse and Strings—Part II
10. Tying Up the Tachyon Monster with Spinning Strings
11. The Invasion of the Anti-Commuting Numbers
12. It's a Bird—A Plane—No, It's Superstring!
13. Gauge Theory—A Brief Return to the Real World
14. Princeton String Quartet Concerti—Part I
15. Princeton String Quartet Concerti—Part II
16. Extra Dimensions—Ether-like or Quark-like?
17. The Fundamental Forces Strung Out
18. Do-See-Do and Swing Your Superpartner—Part I
19. Do-See-Do and Swing Your Superpartner—Part II
20. A Superpartner for Dr. Einstein's Graviton
21. Can 4D Forces (without Gravity) Love Strings?
22. If You Knew SUSY
23. Can I Have that Extra Dimension in the Window?
24. Is String Theory the Theory of Our Universe?

THE TEACHING COMPANY®
The Joy of Lifelong Learning Every Day™
GREAT PROFESSORS, GREAT COURSES, GREAT VALUE
GUARANTEED.™

SAVE UP TO $185!
OFFER GOOD UNTIL FEBRUARY 13, 2007

1-800-TEACH-12 (1-800-832-2412)
Fax: 703-378-3819

Special offer is available online at
www.TEACH12.com/3astr

THE Great Courses®
THE TEACHING COMPANY®
4151 Lafayette Center Drive, Suite 100
Chantilly, VA 20151-1232

Priority Code 21630

Please send me **Superstring Theory: The DNA of Reality,** which consists of 24 half-hour lectures and complete lecture outlines.

☐ **DVD $69.95** (std. price $254.95) **SAVE $185!**
plus $10 shipping, processing, and lifetime satisfaction guarantee.

☐ **Audio CD $49.95** (std. price $179.95) **SAVE $130!**
plus $10 shipping, processing, and lifetime satisfaction guarantee.

☐ **Audiotape $34.95** (std. price $129.95) **SAVE $95!**
plus $10 shipping, processing, and lifetime satisfaction guarantee.

☐ **Check or Money Order Enclosed**

* Non-U.S. Orders: Additional shipping charges apply.
For more details, call us or visit the FAQ page on our website.
**Virginia residents please add 5% sales tax.

Charge my credit card:
☐ VISA ☐ ☐ ☐

ACCOUNT NUMBER EXP. DATE
SIGNATURE
NAME (PLEASE PRINT)
MAILING ADDRESS
CITY/STATE/ZIP
PHONE *(If we have questions regarding your order—required for international orders)*

☐ **FREE CATALOG.** Please send me a free copy of your current catalog (no purchase necessary).

Special offer is available online at www.TEACH12.com/3astr
Offer Good Through: February 13, 2007

BY PHIL HARRINGTON

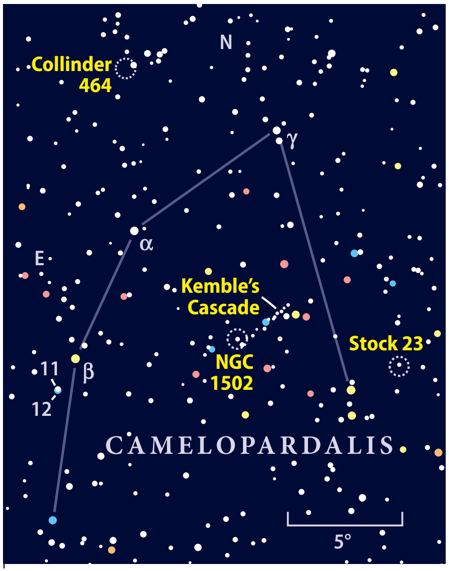
Cascading down the Giraffe's neck

Of all the amateurs I have known, one of the most enthusiastic had to be Father Lucian Kemble, a Franciscan monk from Saskatchewan. I had the pleasure of corresponding with him many times prior to his death in 1999. ☾ Father Kemble loved observing through binoculars and telescopes. His most enduring astronomical legacy revolves around a curious asterism. He bumped into it more than 20 years ago while scanning the faint constellation Camelopardalis the Giraffe with his 7x35 binoculars. Camelopardalis occupies the seemingly starless void between Auriga and Ursa Minor.

After you locate Kemble's discovery, it will help make the Giraffe's dim outline stand out. Aim your binoculars halfway along a line from Capella to Polaris, and look for the 4th-magnitude stars Alpha (α) and Beta (β) Camelopardalis. Before moving on, look south of Beta Cam for a pretty double star formed by 5th-magnitude 11 Camelopardalis and 6th-magnitude 12 Camelopardalis. The stars lie 3' apart, making them easy prey for 7x binoculars.

Now scan approximately 6°, or about a full binocular field, west of Alpha and Beta. Watch for a stream of 14 faint stars shining between 7th and 9th magnitudes flowing southeastward and accented by a lone 5th-magnitude sun about midway. This is **Kemble's Cascade**, a name bestowed on the grouping by famed deep-sky author Walter Scott Houston. Although the stars in this 2.5° string are not physically related to each other in space, they seem to line up with almost military precision.

If you head southeastward along the cascade, you should spot a dim blur next to its last star. That's open cluster **NGC 1502**. Father Kemble likened the view to a waterfall pouring into a pool. The 45 stars that call NGC 1502 home collectively shine at 6th magnitude. My 10x50 binoculars resolve only a few individual points, however; the rest combine to make a triangular glow.



FINDING KEMBLE'S CASCADE will help you navigate to other targets in Camelopardalis the Giraffe. *ASTRONOMY*: ROEN KELLY

Continue another binocular field southwestward to the 5th-magnitude star Struve 385, a binary star often shown representing the Giraffe's front leg. Struve 385 makes a handy marker for our next binocular target, open cluster **Stock 23**. Several observing guides refer to this as Pazmino's Cluster after amateur astronomer John Pazmino, who accidentally stumbled upon it while observing with a small refractor in the late 1970s. Back then, few observers had ever seen, or even heard of, Stock 23, because it was surprisingly missed in both the Messier and NGC listings. Through binoculars, however, it stands out nicely. Of its 25 stars, half a dozen shine between 7th and 9th magnitudes and are visible through 50mm glasses from dark skies. The four brightest form a trapezoid that reminds me of a tiny version of Draco the Dragon's head.

Our final target is **Collinder 464**, another little known open cluster. You'll find it about 8.5° northeast of Alpha Cam. Although the 50 suns that form Collinder 464 are difficult to distinguish from the surroundings, I've always been impressed by a 1° x 2° pattern of 10 stars that includes some from the cluster as well as a few to its north. I always see the stars as a toy poodle's profile. I've christened this asterism "Amy" after my own toy poodle. To my eyes, the dog is facing west with her legs extending to the south and her tail standing at attention to the east. The stars that mark the tip of her nose, ear, and tail look slightly orangish, while the others appear white.

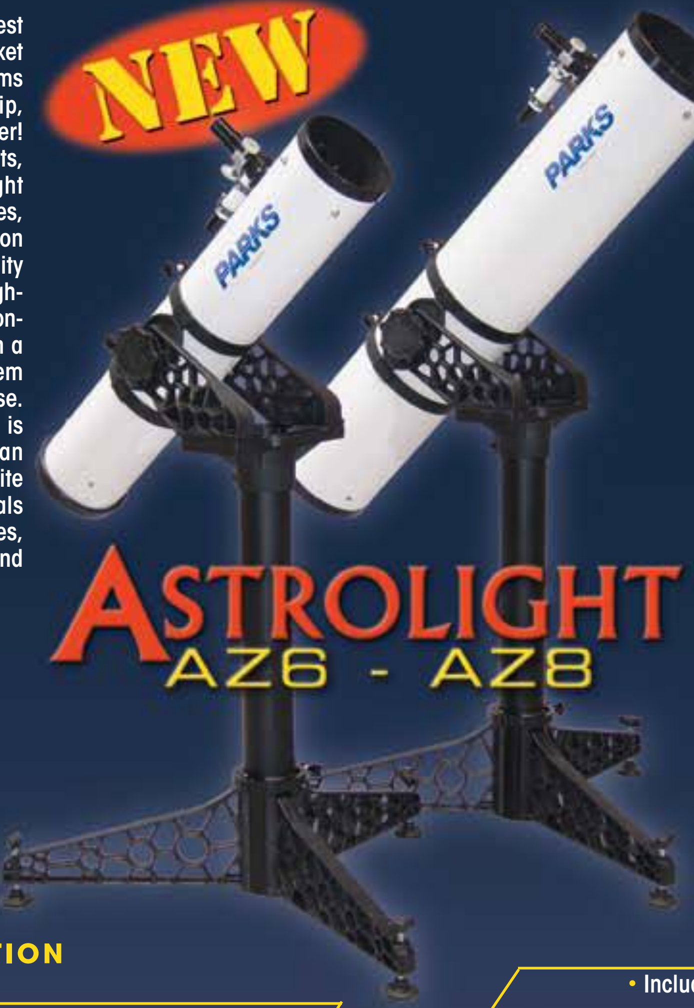
Have a favorite binocular asterism of your own? I would love to hear about it. E-mail me at phil@philharrington.net or send me a note in care of *Astronomy* magazine.

Next month, we return to mighty Orion, my favorite constellation. And remember, when it comes to skywatching, two eyes are better than one!

ONLINE EXTRA For more binocular targets in Camelopardalis, be sure to log on to www.astronomy.com/toc.

TRAVEL THE UNIVERSE FIRST CLASS... AT AN ECONOMY FARE!

Designed and engineered to be the very best performing Newtonian reflectors on the market today, the NEW Parks Astrolight AZ Systems provide superior imaging, craftsmanship, construction and viewing comfort like no other! Delivering superb images of the moon, planets, nebulae and deep sky objects, Astrolight Systems utilize Parks genuine Fiberglass Tubes, Parks LEGENDARY fine annealed diffraction limited Pyrex mirrors and the highest quality mechanical and optical components throughout! Available in 6″ and 8″ sizes, the revolutionary Parks Astrolight Systems are mounted on a very smooth operating alt-azimuth pier system developed for comfort, stability, and ease of use. The NEW light weight Astrolight AZ Mount is a ground-breaking design made from an advanced glass filled, high impact composite ABS material. Beginners and professionals alike will love its features! Sets up in minutes, transports with ease, operates effortlessly, and lasts a life time – GUARANTEED!



INTRODUCTORY PRICE
Astrolight AZ6 $799
Astrolight AZ8 $999

PARKS precision handcrafted optics produce exceptional images!

Utilizes an advanced composite material; extremely tough, yet light weight!

Transporting your Astrolight is a Breeze!

SPECIFICATIONS

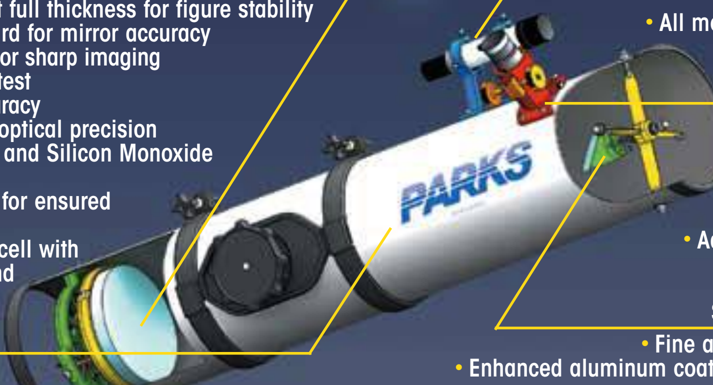
OPTICAL TUBE	AZ6	AZ8
Mirror Diameter	6″/152mm	8″/203mm
F Ratio	f/6	f/6
Focal Length	910mm	1,220mm
Weight	12 lb.	21 lb.
Tube Length	39″	51″

ASTROLIGHT AZ MOUNT	
Height	45″
Weight	25 lb.
Footprint	21″ Radius
Pier Finish	Black Powder Coat
Altitude Range	Horizon to Zenith
Azimuth Range	360 Degrees
Eyepiece Tray	Holds 4 1.25″ Eyepieces

OPTICAL TUBE CONSTRUCTION

PRIMARY MIRROR SYSTEM:

- Made from fine annealed Pyrex mirrors at full thickness for figure stability
- Guaranteed to exceed the industry standard for mirror accuracy
- Guaranteed to be diffraction limited for razor sharp imaging
- Passes the double pass auto-collimation test
- Passes the Foucault test for parabolic accuracy
- Will meet or surpass the Raleigh limit of optical precision
- Aluminized for maximum light reflectivity and Silicon Monoxide overcoated for long lasting performance
- Individually figured, tested and serialized for ensured quality and authenticity
- Secured in genuine Parks primary mirror cell with advanced airflow, thermal equalization and "lock in position" collimation features



GENUINE FIBERGLASS TUBES:

- Rigid and lightweight construction
- Color impregnated gloss white finish that will never peel
- Low thermal conductivity / No thermal expansion
- Flat black, rough textured interior for light absorption and sharper imaging
- Includes protective black End Rings with durable Dust Caps

FINDERSCOPE:

- Includes Parks high quality 6x30 crosshair finderscope with 7° field of view
- All metal construction for finderscope and fully adjustable finderscope bracket

FOCUSER:

- Includes high quality 1.25″ Rack & Pinion focuser
- All metal heavy duty construction
- Precise fit for smooth travel and accurate focusing
- Adjustable tension for proper focusing in all applications

SECONDARY MIRROR SYSTEM:

- Fine annealed, full thickness Pyrex mirrors
- Enhanced aluminum coating for increased light transmittance and brighter images
- Silicone Monoxide coating for lasting protection and longer life
- Secured in fully adjustable flat black aircraft aluminum mirror holders
- Held in place by Parks flat black spider vanes for minimum light loss and maximum stability

PARKS

To order the NEW Astrolight AZ Systems and to see the full line of genuine Parks products, visit **www.parksoptical.com**

AMERICAN MADE

PARKS OPTICAL, INC
750 Easy Street, Simi Valley, CA 93065 USA
805.522.6722 • Fax 805.522.0033

Prices do not include shipping and handling or state taxes where applicable.

HOT PRODUCT 2006 SKY & TELESCOPE

Easy as 1-2-3!
SkyAlign™

The NexStar SLT series.

NexStar 130 SLT

Designed to be an affordable entry level to mid-level computerized GoTo telescope, the SLT refractors and reflectors are available in the most popular sizes and are loaded with valuable design features including:

- High quality optics for bright, clear views of the night sky
- Newly designed fork mount and drive base provide stability and smooth operation
- SkyAlign alignment technology makes setting up and using the NexStar SLT incredibly simple
- Once aligned, use remote hand control to automatically slew to over 4000 celestial objects
- Flash upgradeable hand control for easy upgrades of your SLT's operating software via the Internet
- Auxiliary ports for use with accessories
- Compatible with Celestron's NexRemote™ telescope control software
- Ergonomic design features internal battery compartment and integrated on/off switch

NexStar® SLT Series

[1] Quick-release fork arm mount features an internal battery compartment to prevent cord wrap during use and an auxiliary port for connecting additional accessories.

[2] Motorized altazimuth mount and fully computerized hand control. Includes SkyAlign technology which allows you to align on any three bright celestial objects, making for a fast and easy alignment process.

[3] Sturdy stainless steel tripod with accessory tray. The whole SLT system is designed with quick no tool set up and portability in mind.

[4] NexStar SLT features reflector and refractor models to fit your needs (102 SLT refractor shown here). See our web site at www.celestron.com/slt for complete details.

1

2

3

4

NexStar 60 SLT (2.4″ refractor) shipping and handling $95.00	$279.00
NexStar 80 SLT (3.1″ refractor) shipping and handling $95.00	$379.00
NexStar 102 SLT (4″ refractor) shipping and handling $95.00	$479.00
NexStar 114 SLT (4.5″ reflector) shipping and handling $105.00	$399.00
NexStar 130 SLT (5″ reflector) shipping and handling $125.00	$439.00

Suggested retail in U.S. Dollars. Pricing and shipping charges are suggested for products ordered and shipped in the U.S.A. only.

CELESTRON PREMIER SELECT DEALER

ASTRONOMICS	800.422.7876	www.astronomics.com
OCEANSIDE PHOTO AND TELESCOPE (OPT)	800.483.6287	www.optcorp.com
OPTICS PLANET	800.504.5897	www.opticsplanet.com
TELESCOPES.COM	888.988.9876	www.telescopes.com
SCOPE CITY	800.235.3344	www.scopecity.com
ADORAMA	800.223.2500	www.adorama.com
B&H PHOTO	800.947.9970	www.bhphotovideo.com

CELESTRON®
www.celestron.com/slt

THE ULTIMATE IN ASTRONOMY SHOPPING:
www.adorama.com

MEADE®

AutoStar Suite
MEADE

DEEP SKY IMAGER II / PRO II

Deep Sky Imager II (CLR)	$599.00
CCD Color Filter Set	$199.00
Deep Sky Imager Pro II	$599.00
Deep Sky Imager Pro II w/RGB	$699.00

- **Dramatically lower noise**
- **Larger (1/2” chip)**
- **74% Higher resolution (752x582)**
- **Greater sensitivity**
- **Temperature sensor**

ETX PREMIER EDITION

Automatic Alignment + SmartFinder

Meade's new ETX-Premier Edition automatically levels your telescope, points it to North and sets the time.
You just enter your location or zip code. After your ETX completes its patented Level North automatic alignment procedure it will point to the first alignment star. Use the new wide-field SmartFinder to center the red dot over the alignment stars for ultra-precise pointing accuracy. It’s that easy.

Camera Adaptable

KEY FEATURES

- Electronic Level Sensor
- Electronic Magnetic North Sensor
- High Precision Internal Clock
- Red Dot Viewfinder (SmartFinder™)

ETX PREMIER	Price
90 PE w/UHTC	$749.00
105 PE w/UHTC	$974.00
125 w/UHTC	$1,194.00

PRICES INCLUDE SHIPPING

LEVEL NORTH™ TECHNOLOGY

COME SEE OUR NEW ASTRONOMY SHOW ROOM ON THE 5TH FLOOR

LX90 GPS SERIES

The Meade 8, 10, & 12” LX90
Includes with MgF2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally).

Camera Adaptable

KEY FEATURES

- GPS & Level North Technology
- Smart Drive, Autostar Controller
- Oversize Primary Mirror, Diffraction - Limited Optics
- Rigid Cast Aluminum Fork Mount
- LX-200 Series Tripods
- Smart Finder (Red Dot) & 8x50 View Finder
- AutoStar Suite Astronomer’s Edition Software

LEVEL NORTH™ TECHNOLOGY

LX90	Price
8" w/UHTC	$1,999.00
10" w/UHTC	$2,699.00
12" w/UHTC	$3,299.00

PRICES INCLUDE SHIPPING

LIGHTBRIDGE DOBSONIANS

KEY FEATURES

FEATURES	STANDARD	DELUXE
Diffraction Limited Optics	•	•
Meade Optical Coatings	•	•
2" Crayford-Style machined aluminum focuser w/1.25" adapter	•	•
Red Dot Finder	•	
Advanced Red-Dot Finder (includes four reticles)		•
Steel RA roller bearings		•
26mm Series 4000™ Super Plossl Eyepieces	•	
26mm QX™ Wide Angle 2" Eyepiece (70" field-of view)		•
Built-in Primary Mirror Cooling Fan	•	•

STANDARD	PRICE
8"	$469.00
10"	$649.00
12"	$949.00

PRICES INCLUDE SHIPPING

DELUXE	PRICE
8"	$569.00
10"	$749.00
12"	$1,049.00

ASTRONOMY BINOCULARS

Great for viewing The Heavens

Nikon PENTAX FUJINON Canon MEADE®

We Stock The Complete

WE ALSO STOCK THESE OTHER FINE LINES

Thousand Oaks Optical
LUMICON
PARALLAX INSTRUMENTS
STARLIGHT INSTRUMENTS
TELRAD
STARRY NIGHT
RIGEL SYSTEMS
SWAROVSKI OPTIK
Leica
ZEISS Vixen
SOFTWARE BISQUE

TAKAHASHI

FS-60, Sky-90, FS-102,
TOA-130, LE
Eyepieces, **IN STOCK!**

Check Our Web Site
For Details www.adorama.com

CORONADO

PST, SolarMax
40 Telescopes,
60 & 90mm systems

CORONADO
P.S.T.

Check Our Web Site for a Full Listing

Apogee
INSTRUMENTS INC
Check Our Web Site for a Full Listing

MEADE® DAY

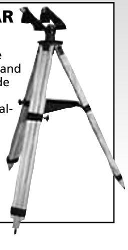
Sunday November 19, Meet The Rep
(Door Prizes) **CHECK OUT THE CORONADO, PST SOLAR SCOPE!**

Tele Vue®

Adorama’s 20th Year Proudly Selling Tele Vue

GIBRALTAR MOUNT

The tripods are finely crafted and American made in a choice of solid ash or walnut wood for beauty and quick vibration dampening. for use with all Telescopes



PLOSSL EYEPIECES

Modest Price With Extraordinary Performance!

BINO VUE

Open both eyes and see the dramatic improvement in resolution, contrast, faint star detection and viewing comfort.

NEW TELE VUE IMAGING SYSTEM TELESCOPES

Same wonderful performance, versatility for the visual observer however with significant added benefits for astrophotographers.

© Jim Burrell

NP127is, NP101is
Available july 2006

Includes:

- New 4 Element, flat field optical design with larger rear lenses for chips up to 50mm diagonal
- New Larger Focuser with 2.4” output diameter,
- Focusmate installed,
- New custom fitted case
- 2” Accssory adapter with clamp ring and photographic adapter

NAGLER EYEPIECES

82° FEILD
“SPACE WALK” VIEWING

PANOPTIC EYEPIECES

TACK SHARP 68° FEILD

BANDMATE FILTERS

Tele Vue Bandmate

DIOPTRX™

EYE SIGHT
Astigmatism correctors

RADIAN EYEPIECES

60° FEILD
20mm Eye-Relief

SHIPPING INSTRUCTIONS See Our Web Site WWW.ADORAMA.COM For Shipping Charges And Relevant Information.

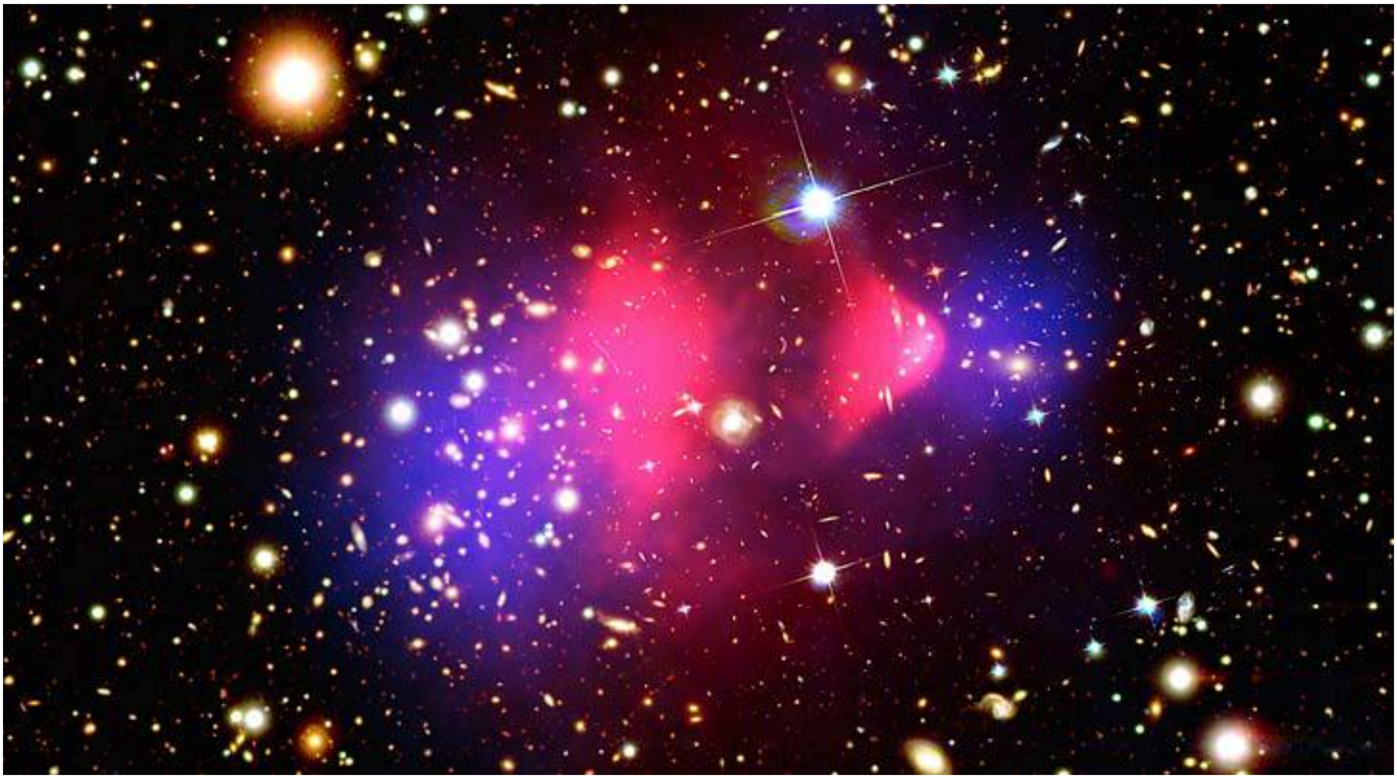
ADORAMA INC.
Source for the **Educated Photographer**

42 West 18th Street New York, N.Y. 10011 info@adorama.com
www.adorama.com • Order Toll Free USA / Canada 800-223-2500
Orders & Information - 212-741-0052

Guest star Chinese astronomers recorded a supernova in December 185. Now, X-ray satellite observations confirm RCW 86 is the explosion's remnant.

For the latest news on
space discoveries,
spacecraft missions,
and sky events, visit
Astronomy.com/news

Astronews



DARKNESS VISIBLE. X-ray-emitting hot gas (pink) traces much of the normal matter in the Bullet cluster, while telescope images show its member galaxies (orange and white). Gravitational-lensing studies (blue) reveal the effects of hidden dark matter.

X-RAY: NASA/CXC/M. MARKEVITCH ET AL.; OPTICAL AND LENSING: NASA/STScI; MAGELLAN/UNIV. OF ARIZONA/D. CLOWE ET AL.

25 Hubble catches rare transit of Uranus moon
26 Jupiter and Neptune may hold "metallic water"
28 Russia's planned space projects recall glory days
30 MRO targets crater gullies

Astronomers find direct evidence of dark matter

Douglas Clowe of the University of Arizona and his colleagues report the first direct evidence of dark matter.

The team combined optical, X-ray, and gravitational-lensing studies of the Bullet cluster (1E 0657–56). In this "traffic accident" between two galaxy clusters, galaxies race through each other at 10 million mph (16 million kilometers per hour).

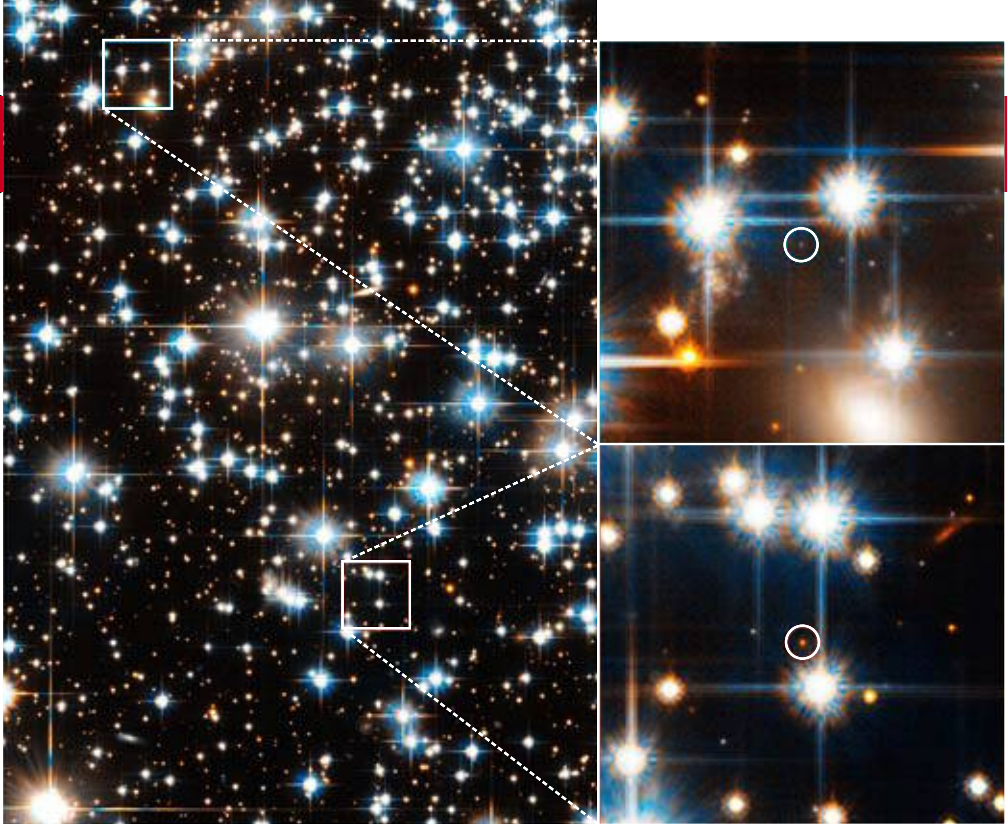
The system's gravity warps space and bends light from more distant objects, a phenomenon called gravitational lensing. But the lensing is most pronounced outside of the gas, on either side of the collision.

Gas in the two colliding clusters interacts, slows, and settles into the center. But dark matter, which responds only to gravity, isn't slowed. "We see that the mass, which is dominated by dark matter, is centered on the galaxies," says team member Dennis Zaritsky of the University of Arizona.

"The significance to me is that it eliminates a nagging worry that we were ignoring a potentially very interesting alternative." That alternative, namely, is that we don't understand gravity.

"We've closed this loophole about gravity, and we've come closer than ever to seeing this invisible matter," Clowe says.

Now that astronomers have proof of dark matter's existence, their next step is to sort out what the mystery matter is. The researchers will publish their results in a forthcoming issue of *Astrophysical Journal Letters*. **— MICHAEL CARROLL**



NASA/ESA/H. RICHER, UNIVERSITY OF BRITISH COLUMBIA

OLD AND DIM. Red dwarfs in NGC 6397 are the faintest stars ever seen in any globular cluster.

Hubble finds cluster's dimmest stars

Astronomers using the Hubble Space Telescope peered deeply into NGC 6397, a globular cluster 8,500 light-years away — one of the closest to Earth. There, they found the faintest stars ever seen in any globular cluster.

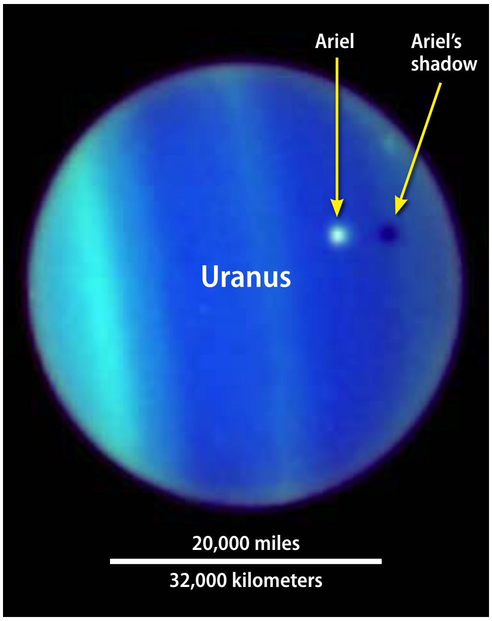
"We have discovered the lowest-mass stars capable of supporting stable nuclear reactions in this cluster," says Harvey Richer at the University of British Columbia at Vancouver, who led the team. Less-massive stars faded early in the cluster's history. They're now too faint even for Hubble to find. The astronomers published their findings in the August 18 issue of *Science*. **— LAURA LAYTON**

Hubble catches rare transit of Uranus moon

On July 26, the Hubble Space Telescope captured a never-before-seen event as Uranus' moon Ariel and its shadow marched across the planet's disk.

Such observations are routine with Jupiter and Saturn. But Uranus is tilted so that its spin axis lies nearly in its orbital plane. The Sun alternately illuminates one pole and then the other as Uranus orbits every 84 years.

Because Uranus' moons orbit in its equatorial plane, transits occur only when we view the planet broadside and its satellites' orbits are edge-on as seen from Earth. Uranus will reach its equinox, when the Sun shines directly over its equator, in December 2007. During the last uranian equinox, in 1965, telescope images of the planet weren't sharp enough to view such events. **— FRANCIS REDDY**



NASA/ESA/L. SROMOVSKY, UNIV. OF WISCONSIN, MADISON

SHADOW PLAY. Uranus' 720-mile-wide (1,160 km) satellite Ariel casts a shadow onto the planet's cloud deck.

QUICK TAKES

SUNRISE IN ORBIT

The Japanese satellite Hinode ("sunrise") launched September 22. Formerly known as Solar-B, the Sun-observing satellite is a follow-on to Japan's 1991 Yohkoh, which demonstrated a link between solar flares and so-called magnetic reconnection events.

FLIGHT TESTS FOR SOFIA

NASA's Stratospheric Observatory for Infrared Astronomy (SOFIA) will undergo at least 3 years of shakedown flights. The Boeing-747-borne telescope could start observing runs by 2012.

NEW SATURN RING

NASA's Cassini spacecraft has found a previously unknown ring around Saturn. The ring coincides with the orbits of Saturn's co-orbital moons Janus and Epimetheus and probably forms as impacts knock dust off the satellites.

RECLASSIFIED

A team of Italian and Brazilian astronomers says an object once classified as a possible faint open cluster is, in fact, the Milky Way's 154th known globular cluster. Called AL 3, the cluster lies 20,000 light-years away in Sagittarius. The research will appear in *Astrophysical Journal Letters*.

NO ICE FOR LUNA?

Radar studies of the Moon's south pole cast doubt on the notion that ice lies buried in permanently shadowed craters there. A team led by Donald Campbell of Cornell University says surface roughness produces the same radar signal as that claimed for subsurface ice.

EUROPA ICEPICK

Inspired by Deep Impact, NASA's 2005 collision with a comet, researchers at Johns Hopkins University are considering a similar mission to Jupiter's moon Europa. The moon is thought to harbor a global ocean beneath a thick icy crust. The crack-up would allow scientists to examine a plume of vaporized Europa ice. **— F. R.**

Canon Image Stabilizer Binoculars turn you into a human tripod.

18x50 IS AW
15x50 IS AW
10x42 L IS WP
12x36 IS II
10x30 IS
8x25 IS

Most ordinary binoculars magnify every little shake of your hand making subjects blurry and difficult to see. But Canon's Image Stabilizer Binoculars help keep things steady by effectively turning you into a human tripod. You can even choose an All-Weather model with water-resistant construction, perfect for use in the field. And they all have a limited 3-year warranty.* So get to your Authorized Canon Dealer to check out the entire line – from 8x to 18x magnification.

Canon
imageANYWARE

©2006 Canon U.S.A., Inc. Canon is a registered trademark of Canon Inc. in the United States and may also be a registered trademark or trademark in other countries. IMAGEANYWARE is a trademark of Canon. All rights reserved. For more information, visit us at www.cusa.canon.com/consumer or call 1-800-OK-CANON. *See website for full details and restrictions.

Jupiter and Neptune may hold "metallic water"

Pure water is a poor electrical conductor — it needs dissolved impurities, like salt, to pass a current easily. But if physicists at Sandia National Laboratory in New Mexico are right, a form of water that conducts electricity better than copper wire may form deep inside the giant planets Jupiter and Neptune.

Sandia's Thomas Mattsson says "metallic water" could occur at temperatures of 6,700° Fahrenheit (3,700° Celsius) and pressures of 1 million atmospheres (100 gigapascals). His study appears in the July 7 issue of *Physical Review Letters*. **— F. R.**

January 1982

25 years ago in *Astronomy*

The January 1982 issue of *Astronomy* featured "Exploring the Suns of Centaurus," an in-depth look at the triple-star system Alpha Centauri, the nearest stars beyond our Sun. The brightest member — indeed, the third brightest in our sky — is a G-type star about 10 percent more massive than the Sun. It and a smaller K-type companion orbit one another every 79.9 years.

The system's third component, an 11th-magnitude, M5-type dwarf dubbed Proxima, is actually the closest to us — 4.22 light-years away. As near as they seem, the stars of Alpha Centauri are beyond our present reach. The Voyager 1 spacecraft, now more than 9.3 billion miles (15 billion kilometers) away after 29 years, would need 77,400 years to get there — assuming it was headed in the right direction.

January 1997

10 years ago in *Astronomy*

Associate Editor John Shibley outlined NASA's first Mars mission with a rover in "Back to Mars on all sixes" in the January 1997 issue of *Astronomy*. This wasn't Spirit and Opportunity, but the aptly named Mars Pathfinder mission and its small rover, Sojourner. The little rover's 3 months of surface operations paved the way for the wildly successful Mars Exploration Rovers, which continue to collect data after 3 years.

Spirit and Opportunity each weigh 18 times Sojourner's 22 pounds (10 kilograms). Wrote Shibley: "What started this year as a testbed should give planetary scientists in the 21st century a luxury of mobility that will yield dividends … in the search for potential martian life." **— F. R.**

BRIEFCASE

Plasma bands

Thunderstorms warp airflow beneath the electrified ionosphere, creating turbulence that may disrupt radio transmissions. The study, based on NASA satellite data, is the first to link weather and Earth's uppermost atmosphere.

Scientists report in the August 11 *Geophysical Research Letters* that storms over South America, Africa, and Southeast Asia formed bands of turbulent plasma 250 miles (402 kilometers) above Earth's equator. **— L. L.**

Ethane cloud

Exposed to sunlight, Titan's methane should break up into ethane. In the September 15 *Science*, researchers using NASA's Cassini spacecraft report sighting an ethane cloud over the moon's north polar area. There, ethane snowflakes may fall on methane lakes. **— L. L.**

Dino boom

A *Proceedings of the National Academy of Sciences* study published online September 5 says two-thirds of dinosaur genera still await discovery. "If you're always finding new things, you probably haven't found them all," says Swarthmore College statistician Steve Wang. He estimates more than 1,800 dinosaur genera may yet be found. **— F. R.**

What was Canon thinking when they expanded the astrophotographer's universe?

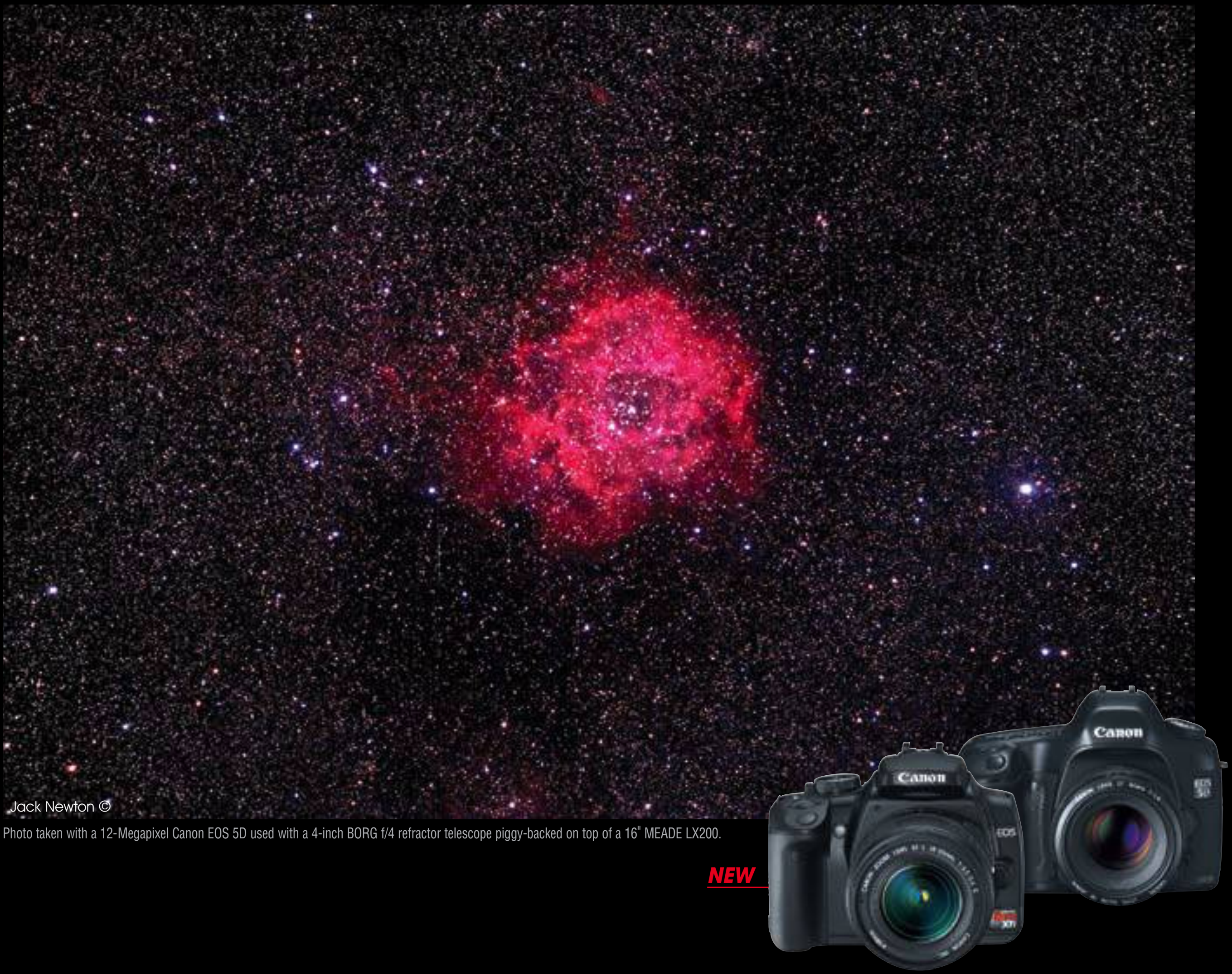


Photo taken with a 12-Megapixel Canon EOS 5D used with a 4-inch BORG f/4 refractor telescope piggy-backed on top of a 16" MEADE LX200.

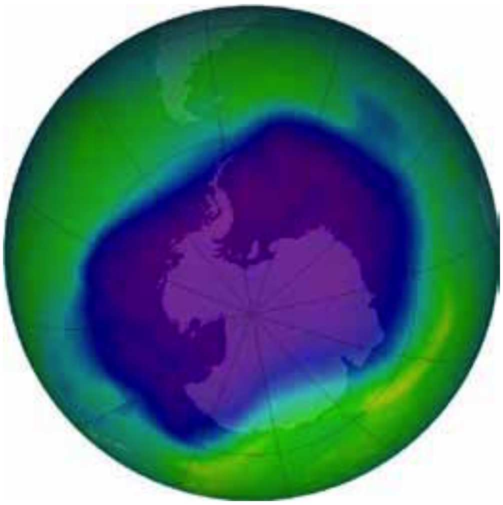
"Exactly what I was thinking."

Jack Newton — Astrophotographer. The universe may be billions of years old, but thanks to Canon, the ways of looking at it are evolving at the speed of light. From Image Stabilizer binoculars to their remarkable lineup of digital SLRs, Canon has made peering at the night sky more rewarding than ever. If what you want to do is look at close-by objects–like the moon, for example–the Canon 18x50 IS All Weather binoculars are a great place to start. They let in an enormous amount of light, while the Image Stabilizer can keep things from jumping around. When it's time to photograph the things you find out there, a digital SLR is a must–and the new EOS Digital Rebel XTi and the EOS 5D are ideal nighttime companions. I've been photographing the heavens almost as long as I can remember, so I know exactly what it takes to get great results. And with cameras like the Digital Rebel XTi and 5D, everyone from amateur stargazers to professional sky watchers can get incredible results. Their low-noise CMOS chip technology is a must for the long exposures needed to capture great images like this one. And for undistorted, edge-to-edge resolution, the full-frame sensor on the 5D is unrivaled. It's just the thing that photographers like me have been asking for. And Canon listened. Which just goes to show, when it comes to space, you have to use your ears as well as your eyes.

Canon
imageANYWARE

IMAGE STABILIZATION • EXCLUSIVE CMOS SENSOR • DiG!C II IMAGE PROCESSOR • OVER 50 EF LENSES

© 2006 Canon U.S.A., Inc. Canon, EOS, EOS Rebel and DiG!C are registered trademarks of Canon Inc. in the United States and may also be registered trademarks or trademarks in other countries. IMAGEANYWARE is a trademark of Canon. All rights reserved. Optional lenses sold separately. For more information, please visit us at **www.usa.canon.com/consumer** or call **1-800-OK-CANON**.



NO-ZONE. NASA's Aura satellite revealed 2006's record ozone hole (purple). NASA

2006 ozone hole sets two records

During the last week of September 2006, the Southern Hemisphere's annual ozone loss reached record values thanks to unusual weather in the stratosphere. At the same time, the hole spanned its largest-ever area —10.6 million square miles (27.4 million square kilometers) on average.

Chlorine and bromine compounds break up ozone above Antarctica when the Sun returns every austral spring. Concentrations of these chemicals have been declining there since 2001, and scientists expect to see the ozone hole decrease during the next decade. But, they say, large year-to-year variations caused by changes in stratospheric weather patterns can mask the hole's slow healing. — **F. R.**

Relativity test

Michael Kramer of England's Jodrell Bank Observatory and his colleagues report in the September 15 *Science* that the binary pulsar PSR J0737–3039A/B confirms Einstein's relativity. The system's pulsars orbit one another every 2.4 hours, but its curved space-time delays their radio waves. Using 2.5 years of data, the team shows the system matches Einstein's theory to within 0.05 percent. — **F. R.**

Russia's planned space projects recall its glory days

NASA

BREAKAWAY. A Russian Progress supply vehicle nears the International Space Station. The nation aims to reclaim its deep-space successes with new science missions.

With their last partially successful deep-space probe, the Phobos Mars mission, almost 20 years in the past, Russian space scientists have begun laying out plans to become major space-science players once again. Buoyed by high tax receipts from oil and gas exports, the Moscow government has authorized initial funding for a menagerie of new missions.

Russia's NPO Lavochkin, the manufacturer that built the Soviet lunar and planetary probes of the early Space Age, now has government contracts for nine deep-space probes. The first, RadioAstron, is slated for launch in 2007. Sporting a 32-foot (10 meters) dish antenna, the craft will be an orbiting radio-astronomy observatory.

Other projects have been widely discussed, including the development of a sample-return mission to the martian moon Phobos. This proposed mission goes by the bizarre-looking moniker Fobos-Grunt (that's "Phobos soil," in Russian).

Spektr-UF, planned for 2010, will carry an ultraviolet telescope with 20 times the sensitivity of Hubble's instruments into an orbit high enough to keep Earth from blocking most targets. Another Spektr payload, one devoted to X-ray astronomy and formerly called Spektr-Roentgen-Gamma, now has been folded in with similar European projects. It carries the ungainly title Spektr-RG/eRosita/Lobster. A Russian Soyuz booster will loft the observatory into a low-altitude equatorial orbit from the French space center in Kourou, French Guiana.

Fobos-Grunt's 3-year round-trip mission, scheduled to begin in 2009, will leave a long-lived science orbiter near Mars. Planners expect to follow it up in 2011–12 with a set of small Mars surface landers.

The Moon is in Russia's sights again, too. Moscow's Vernadsky Institute of Geochemistry and Analytical Chemistry has been out of the lunar-science business for almost 30 years, but it's back with an orbiter called Luna-Glob ("Moon globe"). The probe will search for possible polar ice and also map gravitational irregularities to reveal the Moon's internal structure.

A probe named Intergeliozond ("Inter" for international, "gelio" for Sun, and "zond" for probe) has also been approved to reach nearer the Sun's surface than any previous space mission. After a Venus swingby, the probe's perihelion would be 26 million miles (42 million km). Additional flyby maneuvers will cut that distance by half. An ion drive will also twist the orbital plane until the craft passes over the Sun's polar regions.

The U.S.S.R. had its greatest deep-space success with missions to Venus. In 2013, Venera-D will return Russia to Venus orbit and conduct remote observations. Serious studies have begun for a long-lifetime Venus-lander mission, but no formal project has been approved.

An infrared observatory named Millemetron rounds out the list. Approved for launch by 2015, the cryogenically cooled satellite will observe the sky at infrared wavelengths using a 39-foot (12m) mirror from a high-altitude Earth orbit.

These new names sound weird and unfamiliar, but if the funds keep flowing, the fleet will soon be flying. — **JAMES OBERG**

www.william-optics.com

IBIS 80mm APO Spotting Scopes

Come and experience the APO effects with the handy scope !!

OTA $499

$299

Orange

Blue

ZenithStar 66 SD APO OTA

ZenithStar 80 II ED
(FPL-51) PACKAGES

Includes dielectric diagonal

$998

Megrez 90mm APO
(FPL-53)

A new breakthrough in mechanical and optical perfection

FLT110 TMB Triplet
Air-Spaced

The best optics money can buy!

New

Grab-and-Go
Aluminum tripod

Type: TR-197 (White)
Max height: 206cm

Type: TR-197 (Black)
Max height: 206cm

MOUNT & TRIPOD

EAZY Touch Alt-Az Mount Head	$379
EAZY-T with wooden Tripod and Vixen or COMBO PLATE	from $599
Dovetail+Saddle Plate COMBO	$128
Vixen-style Dovetail Plate	$88

DIAGONALS & PRISMS

90 Deg. Dielectric Diagonals	from $78
1.25 " 45 Deg. Erecting Prism	$68
2" 90 Deg. High Quality Erecting Prism	$248
2" 45 Deg. Erecting Prism	$198

EYEPIECES

Zoom 24-8mm	$148
UWAN 82	from $199
SWAN 72	from $78

E-mail:wo@william-optics.com Tel: +1-714-898-7989

WILLIAM OPTICS

GENUINE LUMICON EQUIPMENT

PREMIUM QUALITY ASTRONOMICAL FILTERS

TELESCOPE COMPUTERS

CAMERA ADAPTERS & EASY GUIDERS

MULTIPLE FILTER SELECTORS

LASER POINTER BRACKETS

LUMICON

DIAGONALS & FOCAL REDUCERS

UTILITY TRAY SYSTEMS

FINDERSCOPES & BRACKETS

Fits Telescopes, Binoculars and Cameras of all sizes!

MADE IN THE USA

NEW Portable Height Adjusting Pier

EXTENSION TUBES & ADAPTERS

THERE IS NO SUBSTITUTE!

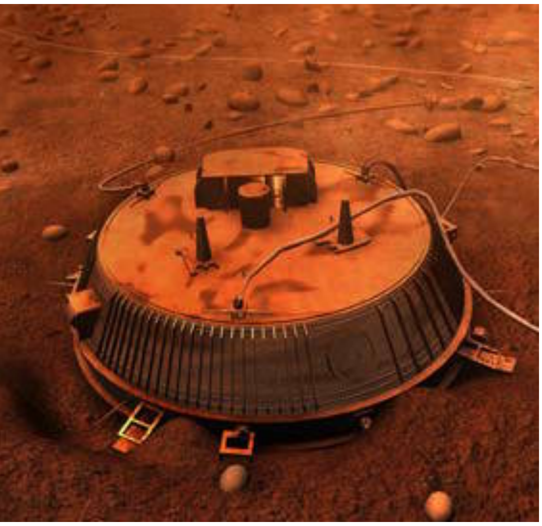
See the full line of genuine Lumicon products and find your nearest authorized dealer at
www.lumicon.com

LUMICON

NEW UNIVERSAL PIER

LUMICON INTERNATIONAL 750 Easy Street · Simi Valley, CA 93065 US 800.420.0255 · 805.520.0047

1 in 3 U.S. adults are among the least accepting of evolution, with 1 in 3 rejecting it, according to a 34-country study by Michigan State University's John Miller.



ESA

FREE DATA. Radio signals from the Titan-landing Huygens probe, shown on the moon in this illustration, gave scientists unexpected information.

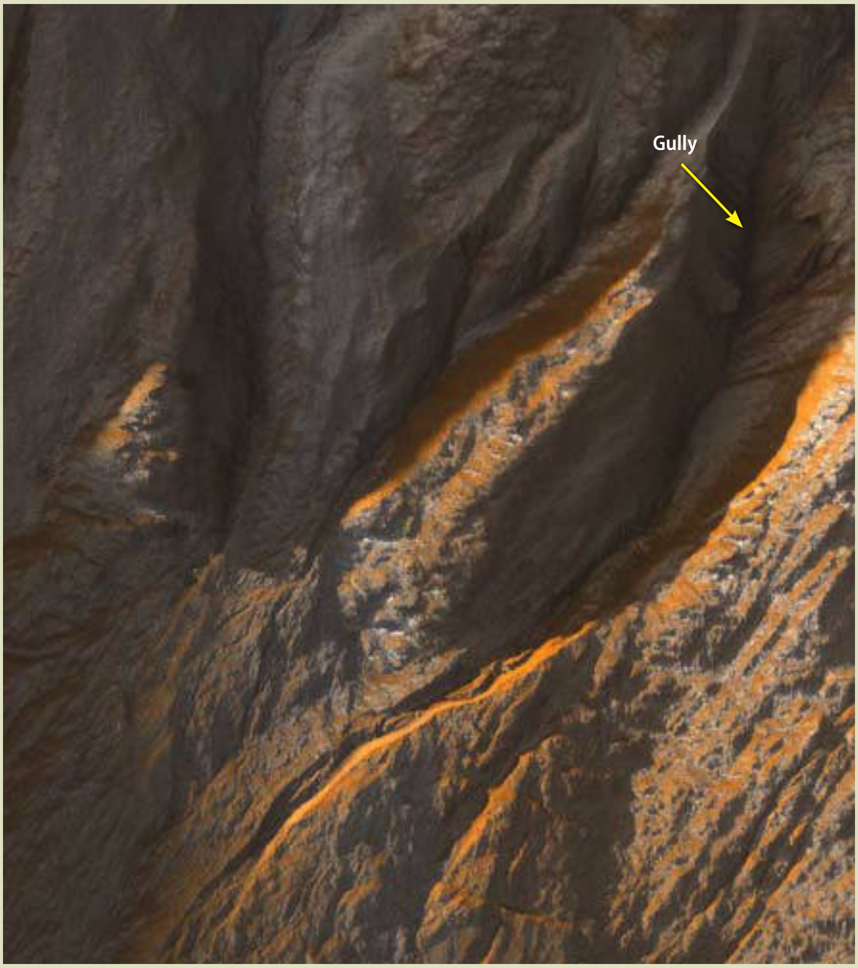
Huygens probe "sees" Titan's pebbled surface

Radio signals sent while the European Space Agency's Huygens probe sat on Titan provided an unexpected snapshot of the moon's frozen surface.

When Huygens touched down on Titan January 14, 2005, it transmitted data to NASA's Cassini spacecraft for another 71 minutes. Part of this signal first reflected off Titan's surface before heading to the orbiting Cassini. On the way, the reflected signals interfered with the direct beam.

Miguel Pérez-Ayúcar, a member of the Huygens team, and his colleagues found the signal Cassini received was sensitive to pebble sizes on Titan's surface. The signals encoded surface information ranging from 3 feet (1 meter) to more than a mile (2 kilometers) west of Huygens. This swath, he says, must be relatively flat and covered mostly in stones between 2 and 4 inches across (5 and 10 centimeters)

Pérez-Ayúcar says that, with a few refinements, this will be a powerful technique for future landers. — **F. R.**



NASA/JPL/UNIVERSITY OF ARIZONA

FROSTY MARS. Frost appears blue-gray even in shadow in this MRO image. A dark gully may result from seasonal melting. The scene is about 830 feet (254 meters) wide.

MRO targets crater gullies

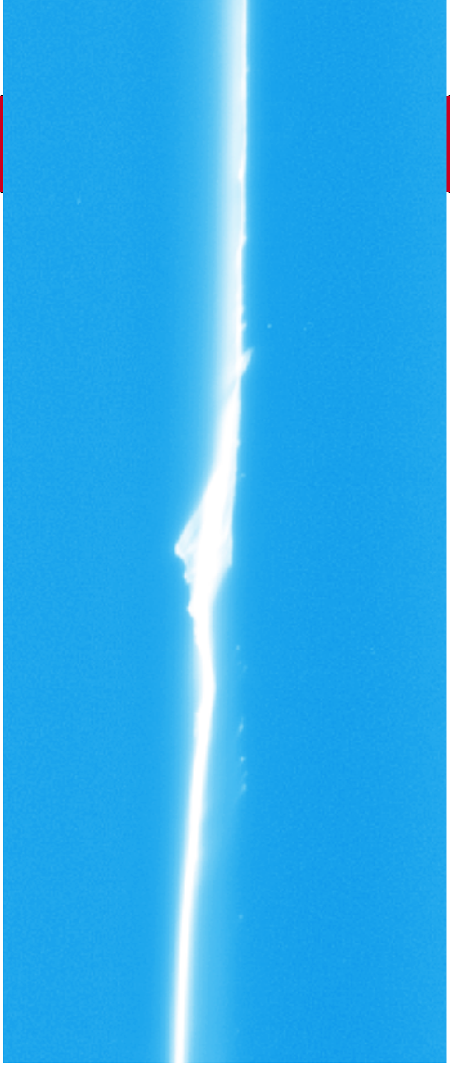
NASA's Mars Reconnaissance Orbiter (MRO) imaged fresh gullies in an unnamed Terra Sirenum crater October 3. The image was one of 9 released as the spacecraft prepared to begin its primary science mission.

Although it is southern winter on Mars, and the low afternoon Sun put much of the crater in shadow, MRO's sensitive High Resolution Imaging Science Experiment (HiRISE) recorded the subtle colors. Scientists say bluish areas are most likely a water-ice frost. Bright reddish zones are where frost recently sublimated. Dark regions, such as gully channels, reveal the most recent activity and may form as a result of seasonal melting. — **F. R.**

Hubble spots Uranus cloud

Lawrence Sromovsky of the University of Wisconsin-Madison led a team that took the first definitive images of a dark, elongated cloud on Uranus. While not unusual on Neptune, such features have been sighted only rarely on Uranus.

The astronomers used the Hubble Space Telescope to image the 1,100-by-1,900-miles-wide (1,700 by 3,000 kilometers) feature. The onset of a Uranus storm season may coincide with the planet's December 2007 equinox. — **F. R.**


NASA/JPL/SSI

DISTURBED. Saturn's rumpled F ring points to embedded moonlets.

Saturn's F ring hides moonlets

Never-before-seen details in Saturn's clumpy F ring suggest one or more undiscovered moonlets lie within it. Cassini's narrow-angle camera spotted the strange structure September 25.

As small satellites close in on the F ring's dense core, their gravity sometimes draws out streamers of material. Cassini scientists say they've seen this before. In August 2005, the spacecraft imaged a larger-scale version in the wake of Saurn's 63-mile-wide (102 kilometers) moon Prometheus.

Scientists speculate that several small moons with a variety of sizes could be responsible for the newly seen structures.

Cassini imaged the F-ring clump when the spacecraft was 159,000 miles (255,000 km) from Saturn. Scientists magnified the image and enhanced its contrast. — **F. R.**

Vixen Optics

At Vixen, we pride ourselves on the *adaptability* of our optical products. Whether you are just starting out, or you are an experienced amateur, enjoy the experience that Japanese amateurs have relished for decades - **premium quality optics at affordable prices.** (For example, Vixen's 70mm refractor is just $139). From small refractors to large Newtonians, from smoothly performing simple mounts to powerful GOTO mounts, from eyepieces to finder scopes, from small binoculars to larger models, Vixen enables you to design the best combination of equipment for your viewing pleasure. With our interchangeable mounts, telescopes, eyepieces, and binoculars,

New longer warranty on telescopes and binoculars!

Vixen has what you need to be whatever kind of astronomer YOU want to be.

Visit the new Vixen Optics site and discover our full line of products. We have factory authorized dealers who possess high standards you would expect from a quality manufacturer like Vixen. We list some of them below.

VixenOptics.com

Visit our factory authorized dealers:

Telescopes.com
Proctor, MN
800-303-5873
telescopes.com

Woodland Hills Telescope
Woodland Hills, CA
888-427-8766
whtelescopes.com

Oceanside Photo & Telescope
Oceanside, CA
800-483-6287
optcorp.com

Rivers Camera & Telescope
Dover, NH
800-245-7963
riverscamera.com

astronomics™ . . . our 28th year.

The optical center of the known Universe.™

We've been helping people choose the right telescope since 1979. We have the experience (a staff total of over 150 years of experience using and selling telescopes) to help *you* pick the telescope that fits your needs (and your budget). And, with our seven-figure inventory, we can usually ship you the right scope, right away, from the hundreds of scopes we stock.

We started ***astronomics*** over 27 years ago because we loved astronomy,

Don't miss your last chance to enter online to win a $4000 telescope!

You have only until December 31st to register for your chance to win a great prize in the *free* Astronomics Giveaway!

The top prize is a **TMB Optical TMB130 *Signature Series*** 5.1" ED triplet apochromatic refractor with mounting rings. Worth $4000, it could be yours *for free!*

Or you might win a $399 **Celestron SkyScout** Personal Planetarium – one of the hottest (and hardest to get) accessories this year. Other prizes still available include a $495 set of *five* **Burgess/TMB** planetary eyepieces, a $200 **Astronomics** gift certificate, and a $190 **Astro-Tech** 2" *quartz dielectric* star diagonal.

To win, visit **www.astronomics.com** and enter. No purchase is necessary

The usual fine print rules apply: only one entry per household, only one prize-winner per household, etc.

A new TMB 5.1" ED triplet apo . . . $3790. Why wait?

$3790

TMB 130 triplet apo

Tired of being on a multi-year waiting list for other premium apochromatic optics that never come?

Here's a better idea. The first of the new TMB *Signature Series* apo ED triplet refractors from **TMB Optical** *is available now!*

This superb triplet uses top-quality FPL-53 ED glass for a level of apo color correction that impresses even its creator, renowned designer Thomas M. Back.

The 130mm f/7 **TMB-130 Signature Series** apochromatic refractor uses a fully multicoated ED air-spaced triplet lens in a collimatable and temperature compensated cell. Its rotating dual-speed 4" focuser is ideal for medium format and CCD photography. It has both 2" and 1.25" compression ring eyepiece adapters, a self-storing retractable lens shade, dust covers, and a fitted hard case.

Nine accessories for $49 when you buy a Celestron.

Buy any Celestron telescope priced at $199 and up before 12/31 and this **Celestron Accessory Kit** is yours for only $49!

You get 12.5 and 32mm 1.25" Plössl eyepieces, a 1.25" 2x Barlow lens, four 1.25" filters for lunar and planetary observing (orange, blue, green, and neutral density), a no-battery flashlight that generates and stores power just by shaking it, and a fitted aluminum-finish case – *and they're all yours for only $49!*

Find Orion at Astronomics without a star chart.

$179^95

$1099^95

Orion Atlas-GT mount

$1429^95

We're not talking about the constellation of Orion. We're talking about **Orion** telescopes and accessories.

We stock Orion Dobsonian reflectors in all sizes. For the kids, there's the **SkyBlast** 4.5" tabletop model to the left, and the 4.5" SkyQuest, not shown, at $229.95. We stock 6" to 12" **SkyQuest** Intelliscope Dobs starting at $479.95 (the 12" version is shown to the right). Each has a right-angle finder, laser collimating tool, and a handheld Intelliscope object locating computer that will lead you quickly to over 14,000 celestial objects.

If you have your own optics, the 40 lb. payload capacity **Orion Atlas-GT** *go-to* equatorial mount will carry them for $1429.95. It's the ideal step between low price/small payload mounts and big payload mounts at budget-busting prices. You can train its go-to computer to find objects with 1 arc minute accuracy!

You'll find many more Orion products on our **www.astronomics.com** website.

Your car's back seat will hold a 16" Meade LightBridge.

Meade 16" f/4.5 LightBridge

$1999

Meade LightBridge Dobsonians use a truss-tube design that lets even the big 16" model break down into a few small packages that fit into most compact cars.

All LightBridge Dobs have a 2" machined aluminum Crayford focuser; 1.25" eyepiece holder; 2" 26mm 70° field QX eyepiece, and an illuminated finder with four reticle patterns. Roller bearings provide smooth hitch-free motion at the touch of a finger. A battery-operated fan on the metal primary mirror cell assures fast cooling of the diffraction-limited BK7 optical glass mirror. No tools are needed to assemble and break down each scope in the field.

The prices below include the shipping from the Meade factory.

8" f/6 LightBridge	**$599**
10" f/5 LightBridge	**799**
12" f/5 LightBridge	**999**
16" f/4.5 LightBridge	**1999**

Is this Paragon the ultimate wide field eyepiece?

$249

Many buyers believe that the 2" 40mm **TMB Paragon** truly *is* the best ever.

It has a wide 68° true field, tack-sharp images from edge to edge, good eye relief, and great contrast. A reviewer said his first impression of M13 at a mere 35x in the Paragon "was of a pinch of diamond dust on a black background; even at this low magnification, it was possible to see the 'dust' as a cloud of pinpoint stars."

This visually stunning eyepiece takes wide field viewing to an entirely new level, at a price/performance ratio no other quality eyepiece can touch.

"Ritchey-Chrétien-like" Meade performance . . . but at only a fraction of an R-C's price.

Meade 8" f/10 LX200R Ritchey-Chrétien

$2674

freight paid

Sky & Telescope said the new Meade R-Series catadioptric "does indeed perform like a Ritchey-Chrétien." And *Astronomy* said it "delivers Ritchey-Chrétien-like performance at a fraction of the cost."

Why pay $14,000 to $34,000 for the flat field of a true Ritchey-Chrétien reflector optical tube – and still have to pay for a mount? Get the catadioptric that reviewers call "Ritchey-Chrétien-like" in a complete scope/go-to mount combo starting at under $2700!

8" to14" Meade LX200R go-to scopes usually ship from our stock, so you can get yours fast. And if you live in California, that saves you the sales tax, too.

Here are the *freight-paid* prices on the LX200R Meades that we ship from our stock:

8" **LX200R,** with UHTC optics	**$2674**
10" **LX200R,** with UHTC optics	**3634**
12" **LX200R,** with UHTC optics	**4694**
14" **LX200R,** with UHTC optics	**6349**

Because of their weight, these 16" LX200R scopes ship to you via truck from Meade.

16" **LX200R,** without mount, w/UHTC	**$11,529**
16" **LX200R,** tripod, w/UHTC	**12,494**
16" **LX200R,** altaz pier, w/UHTC	**12,524**
16" **LX200R,** eq pier, w/UHTC	**12,779**

In 1979, an 8" Celestron cost $1295, and was worth it. $1399 buys you an even better *go-to* Celestron 8 today.

$799

Celestron NexStar 5SE 5" Schmidt-Cassegrain

That state-of-the-art 1979 scope would cost $3667.08 in today's dollars – and it wouldn't have a go-to computer, multicoated optics, or a Plössl eyepiece like today's $1399 **Celestron NexStar 8 SE.** It *would* have Celestron's superb optics, however. That's one thing that hasn't changed over the years.

All **Celestron NexStar SE** go-to scopes have no-guesswork *SkyAlign* computers that find celestial objects for you automatically; Celestron's best Starbright XLT multicoatings; and more.

Each optical tube comes off its fork arm in seconds without tools to use on a photo tripod as a spotting scope.

The NexStar SE Series scopes that we keep in stock include:

NexStar 4 SE, 4" Maksutov	**$599**
NexStar 5 SE, 5" SCT	**799**
NexStar 6 SE, 6" SCT	**999**
NexStar 8 SE, 8" SCT	**1399**

New lower prices on the Meade LX90 GPS.

Meade 8" LX90 GPS w/UHTC

$1999

freight paid

Meade LX90GPS 8", 10", and 12" go-to Schmidt-Cassegrain telescopes with multi-coated UHTC optics have GPS (Global Positioning Satellite) technology that makes it easier to find your way around the sky.

And now they have lower prices to make owning one easier on your wallet, too.

You don't have to tell an LX90 where or when you are on earth in order to find any of the more than 30,000 celestial wonders in its memory. Its GPS receiver gets that information from a net of 24 Earth-orbiting satellites, then moves to two alignment stars – *all automatically!* Simply check that your LX90's finder is centered on those two stars, then start enjoying computerized go-to observing. A Meade LX90GPS makes astronomy that easy!

We keep LX90s in stock, so we ship faster than dealers who have to order them from Meade (and if you live in California, we save you the sales tax, too).

Here are the *freight-paid* prices on the LX90s that we ship from our stock:

8" LX90GPS, UHTC optics	**$1999**
10" LX90GPS, UHTC optics	**2699**
12" LX90GPS, UHTC optics	**3299**

Celestron *SkyAlign* go-to scopes start at a low $279.

$379

80mm Celestron NexStar 80 SLT

You don't need to know the Pleiades from Polaris to find your way around the skies with a **Celestron SLT** go-to scope. With Celestron *SkyAlign* technology, just point your SLT at any three of the 50 brightest lights in the sky (3 stars, or 2 stars and a planet), and the SLT will find the planets and over 4,000 deep space objects for you *automatically.* A few anonymous points of light are all you need to find celestial wonders like a pro.

Celestron SLT no-guesswork go-to scopes are available in these sizes:

NexStar 60, 60mm refractor	**$279**
NexStar 80, 80mm refractor	**379**
NexStar 102, 102mm refractor	**479**
NexStar 114, 114mm reflector	**399**
NexStar 130, 130mm reflector	**439**

Each has *two* eyepieces, red dot finder, motor drives, stainless steel tripod, NexStar computer, software to control the scope from your computer, and more.

astronomics™

The optical center of the known Universe.™

Our 28th year of friendly service, reliable advice, and money-saving prices.

680 24th Avenue SW, Norman, OK 73069

Toll-Free Telephone: **(800) 422-7876** If the toll-free telephone lines are busy: **(405) 364-0858**

Toll-free from the 50 United States and Canada.

Anyone can sell you a telescope.
We'll sell you the right telescope.™

not just as a business. Our sales may have grown over a thousand-fold since that first year, but we're still the same family-owned, family-run, full-line telescope dealer we were in 1979. And we still love astronomy.

astronomics. No hard sell. No guesswork. Just honest advice, the time to make sure you get the right telescope and accessories, and a good price. Call us toll free at (800) 422-7876 and find out for yourself.

Order by 12/20 and you still have time to get one or more of these \$2^{49} to $99 holidays gifts!

Here's a tasty smorgasbord of very affordable observing aids that are sure to please any astronomer. Give one or more to your favorite observer. Better yet, leave a copy of this ad on the kitchen table with the items *you* hunger for neatly circled in red. Santa is bound to notice your subtle hint.

Gifts under $30 . . .

Eyepiece cases start at only $2.49. Our seven bolt-type plastic containers keep your eyepieces and filters free from dew and dust. Foam inserts cradle eyepieces to protect against accidents. **www.astronomics.com** lists the eyepieces that fit each container.

Show your colors (as long as they're blue and white) for $12.95! Astronomics T-shirts are preshrunk 100% cotton in midnight blue. They fit adult sizes L, XL, XXL, and XXXL. The Astronomics logo is on the front. A glow in the dark map on the back shows the location of The Optical Center of the Known Universe™.

Observing books for as little as one-third their regular price.

Stars & Galaxies: Our part #A9566. This 200-page hard cover includes 344 of the most fascinating deep sky objects for scopes of all sizes. Regularly $29.95, it's sale priced at only **$9.95**.

Galaxies & The Universe: This 112-page soft cover helps you find hundreds of galaxies with scopes 8" and larger. Our part #A9573. Regularly $19.95, it's sale priced at only **$7.95**.

Eyepiece color filters for planetary observing for only $14.95 each. There are 12 different **Meade** Series 4000 1.25" eyepiece filters for enhancing your views of the planets. Buy them individually at $14.95, or in sets of four that save you almost $10 per set over the cost of buying the filters separately.

And there are four similarly value-priced **Celestron** filter sets for lunar and planetary observing. They have various combinations of color filters, a polarizer, and neutral density filters.

There is also a **Meade** ND9 neutral density filter for observing the Moon without squinting at **$16.95** and a green **Celestron** Moon filter for **$13.95**.

LED flashlights start at only $19.95. Red LED night vision flashlights protect your dark-adapted vision while you're observing. The **Celestron** variable brightness light (our part #VLED) is **$19.95**. The **Rigel Systems** mini variable brightness light, #4393, is **$19.95**. Rigel's larger water-resistant version (great if dewing is a problem), #4591, is **$24.95**. The **Rigel Systems** two-color variable brightness mini (#4594) – a red light for reading star charts, and blue-white for setting up and taking down your scope – is only **$24.95**. Rigel's larger water-resistant two-color version, #4592, is **$29.95**.

Gifts from $30 to $60 . . .

The best CCD book is $49.95. Before you spend $3000 on a CCD camera (or even $300), spend **$49.95** on this very informative book. **The New CCD Astronomy** by Ron Wodaski is the best and most complete imaging reference available for CCD photographers of all skill levels. It includes everything you need to know to become proficient at CCD imaging, plus you get a free subscription to on-line updates and reference materials.

Vibration suppression pads stop your scope's jitters. Put these handy pads under the legs of your telescope or spotting scope tripod to effectively end the tremors that blur your view for a few seconds each time a breeze comes up or you touch the scope to focus. A set of three **Celestron** vibration suppression pads, our part #VSP, costs **$49.50.** The set of **Meade** vibration isolation pads to the right, our part #895, costs **$49.95.** Both sets will improve your observing and are well worth the modest investment.

Power to the people! Buy one Power Tank instead of hundreds of flashlight batteries. **Celestron** Power Tank high capacity rechargeable batteries have the power to run your scope and accessories all night long. They can be recharged hundreds of times, saving you hundreds of dollars over the cost of buying flashlight batteries every few weeks. Each has *two* 12V DC cigarette lighter outputs; 3, 6, and 9V DC outputs for accessories; an emergency spotlight; built-in recharger; shoulder strap; carry handle; and more. The 7 amp hour Power Tank to the right, our part #4512V, is only **$59.95**. A 17 amp hour Power Tank is also available for $92.95.

Gifts from $60 to $100 . . .

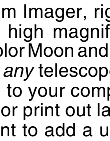
Get more star diagonal. Pay less money. How much should you have to pay for a 1/10th wave 99% reflectivity dielectric mirror star diagonal with a compression ring eyepiece holder? Less than you might think! The **Astro-Tech** 1.25" dielectric diagonal shown, our part #AT1D, is only **$69.95** and worth every penny!

We also have 2" **Astro-Tech** dielectric compression ring diagonals, each with a separate 1.25" compression ring eyepiece holder, available for both refractors and Schmidt-Cassegrains.

See more, pay less! The **TMB** Planetary eyepieces at **$99** may shake up your beliefs about how much you have to pay for a quality eyepiece from a famous designer. They were created by noted optics designer Thomas M. Back to complement the performance of the state-of-the-art apochromatic refractors he designs that cost as much as $92,990. When your scopes cost that much, you don't design eyepieces that will limit their performance. And the 2.5, 3.2, 4, 5, 7, 8, and 9mm TMB 1.25" long eye relief Planetary eyepieces won't limit the performance of your telescope, either, whether your scope cost $92,990 or $299.

6
Planetary Series

Picture the planets for $99. Take your choice of a **Meade** LPI Lunar Planetary Imager, left, or a **Celestron** NexImage Solar System Imager, right. Each takes high magnification full-color Moon and planet images with *any* telescope and sends them to your computer to view live or print out later.



If you want to add a useful accessory to the NexImage camera, consider the NexImage Reducer Lens at $24.50. It doubles the field of view for wider lunar panoramas. Another accessory to consider is the $57.95 NexImage 1.25" UV/IR filter. It gives sharper planetary surface detail with *all* CCD cameras.

Get a $399 Deep Sky Imager Pro CCD camera for $129 when you buy a Meade telescope.

The **Meade Deep Sky Imager Pro** CCD camera sells for $399. But now, while supplies last, you can get the DSI Pro for only $129 when you buy a Meade LXD75, LX90, LX200, or RCX400 telescope!

The monochrome DSI Pro is loaded with features like NASA-developed "Drizzle" software that sharpens the resolution and quadruples the size of your LX90, LX200, or RCX400 deep space photos. And the filter set for tricolor imaging, normally $199, is only $99 if bought with camera and scope.

The DSI Pro opens up a whole new way to observe with a Meade telescope. Best of all, you save a total of $370 on the DSI Pro and color filter set when you buy them along with your LXD75, LX90, LX200, or RCX400.

Give the gift of brass this Astro-Tech holiday season.

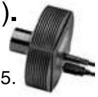
There is still time this holiday season to give a brass telescope to perk up someone's office or home decor. While most brass scopes are over-priced and not very good optically, that's not true of the apochromatic (color-free) **Astro-Tech AT-66ED**. This 66mm f/6 ED scope has superb optics, rotating dual-speed Crayford focuser, choice of colors, and hard case. It fits any photo tripod. Its anodized brass-look finish won't tarnish in time the way ordinary brass does.

$329

Astro-Tech AT66ED, in brass, chrome, black, blue, green, red, burnt orange, or white

The Orion StarShoot Deep Space CCD is cool(ed).

The **Orion StarShoot** is a single-shot full color CCD camera. Unlike other CCDs in its price range, it has a built-in thermo-electric cooler for cleaner and less noisy warm weather pics. It's cool and cooled for $399.95.



Give the gift of the heavens this holiday season.

The **Celestron SkyScout** makes it easy to find your way around the heavens. This award-winning handheld non-magnifying GPS-based personal planetarium identifies or locates more than 6,000 celestial objects visible to the unaided eye, then tells you their facts and history.

There's a scrolling 5-line text and graphics display. Supplied earbuds and optional speakers let you hear the text, too.

SkyScout transforms the night sky into a planetarium for families, stargazers, and students. It makes identifying what's in the sky easy for once.

$399
freight paid

You'll find thousands of *unbiased* equipment reviews at www.cloudynights.com

> After talking to you, it was heartening to note that there are still people in the business community that have the customers interests in mind. You were very helpful specially after I told you that I was a novice in Astronomy and that this would be my first "real" telescope. Thanks again for your kind attention. I would have no qualms in recommending your firm to any of my friends.
>
> **Customer Quote of the Month #178**

Need a gift? It's hard to beat this $209 Konus.

With this **Konus**, how much you get for how little you pay is downright amazing.

If you're not looking for go-to, but just want a good scope to get or give for casual viewing, this optically nice 90mm (3.5") **Konusmotor-90** f/11 refractor is a great buy. It has an equatorial mount with adjustable tripod, 6 x 30mm finderscope, battery-powered motor drive so you can use it anywhere, and *two* 1.25" Plössl eyepieces!

It's one of our best sellers because it's a great value at $209. And there are other Konus motor drive scopes from $109 to $799.

$209

3.5" f/11
Konus refractor

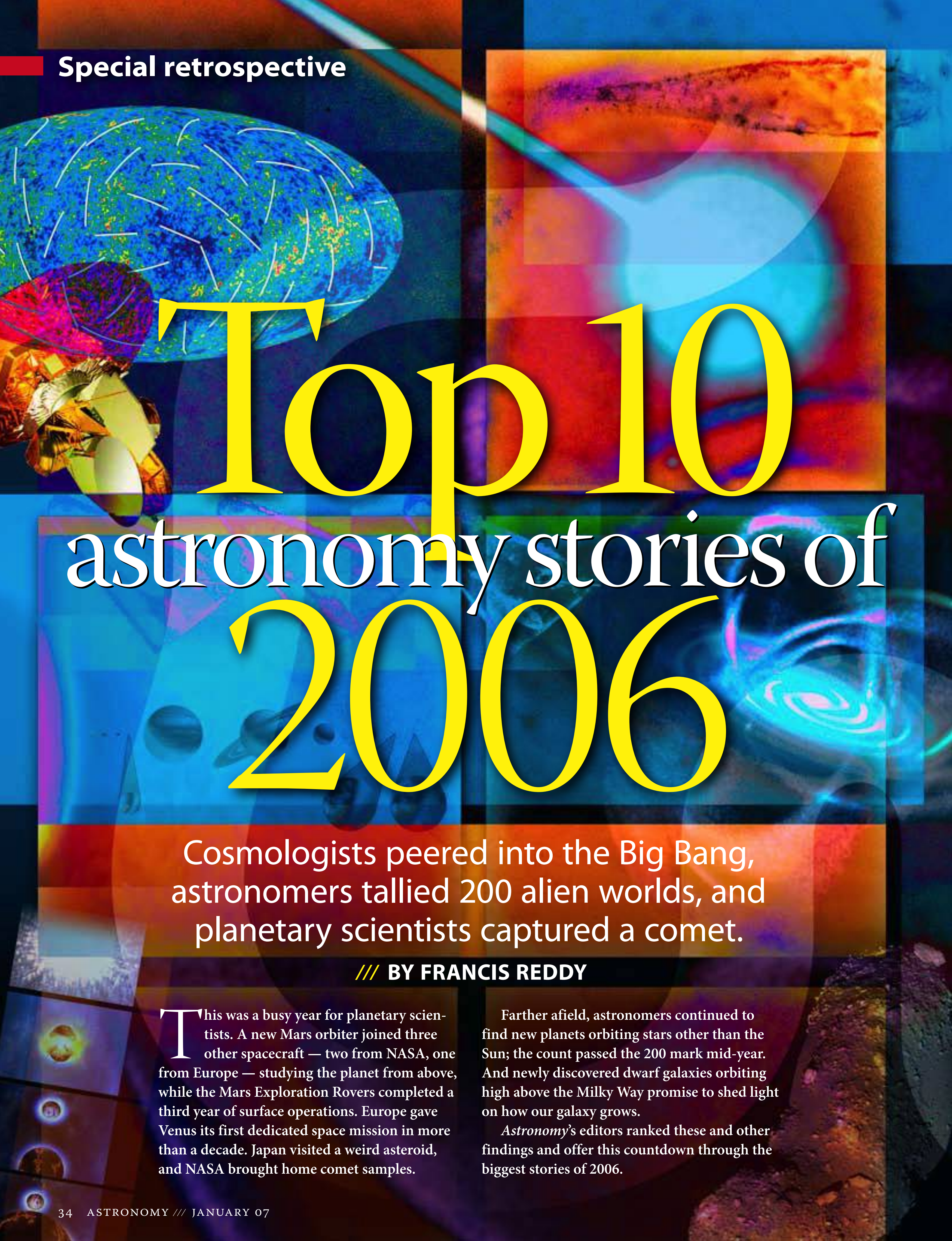
24-Hour FAX line: (405) 447-3337 Our e-mail address: questions@astronomics.com
Our award-winning Internet site: www.astronomics.com Mastercard, Visa, Discover, American Express.

PHONE HOURS: 8 to 9 CST Monday thru Friday, Saturday 12 to 5. STORE HOURS: 9 to 5 Monday thru Friday, Saturday by appointment.

U. S. sales *only* – except for Meade and Takahashi which are also available for sale to Canada. Prices, special offers, and specifications are current as of 10/10/06, but are subject to change. $7.95 minimum freight. All returns less freight. Restocking fees apply to returns for credit and to merchandise returned used or damaged. **We meet or beat any advertised price.**

Price match fine print: competitor's price must be verifiable and available nationally; chain store, close-out, and going-out-of-business prices are excluded; no retroactive price matching; a package price must be from a single competitor.

Special retrospective



Top 10 astronomy stories of 2006

Cosmologists peered into the Big Bang, astronomers tallied 200 alien worlds, and planetary scientists captured a comet.

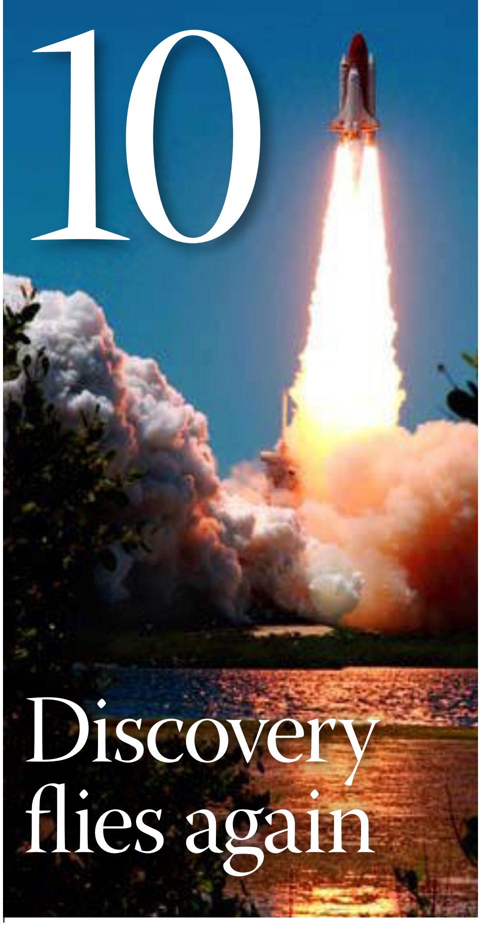
/// BY FRANCIS REDDY

This was a busy year for planetary scientists. A new Mars orbiter joined three other spacecraft — two from NASA, one from Europe — studying the planet from above, while the Mars Exploration Rovers completed a third year of surface operations. Europe gave Venus its first dedicated space mission in more than a decade. Japan visited a weird asteroid, and NASA brought home comet samples.

Farther afield, astronomers continued to find new planets orbiting stars other than the Sun; the count passed the 200 mark mid-year. And newly discovered dwarf galaxies orbiting high above the Milky Way promise to shed light on how our galaxy grows.

Astronomy's editors ranked these and other findings and offer this countdown through the biggest stories of 2006.

ASTRONOMY: KELLIE JAEGER



10

Discovery flies again

NASA/SANDY JOSEPH AND ROBERT MURRAY

STS-121 made its own July Fourth fireworks as Discovery blasted to space on its third launch attempt.

The near-flawless July mission of STS-121 completed NASA's return to flight following the February 2003 Columbia tragedy. The flight cleared the way for new construction at the International Space Station (ISS) and offers the possibility that astronauts will service the ailing Hubble Space Telescope.

NASA engineers removed a two-piece, 34-pound (15 kilograms) foam structure called a PAL ramp from STS-121's external tank. Shuttle program manager Wayne Hale called the fix "the largest aerodynamic change to this vehicle" since the shuttle started flying. During STS-114 in July 2005, a yard-long foam chunk — one nearly the size of the piece that fatally damaged Columbia — popped off the PAL ramp but didn't strike Discovery.

Discovery blasted off July 4, 2006, with Steve Lindsey commanding a crew of six. They included Pilot Mark Kelly and Mission Specialists Michael Fossum, Lisa Nowak, Stephanie Wilson, and Piers Sellers; and the European Space Agency's (ESA) Thomas Reiter from Germany, who stayed aboard ISS. Reiter's arrival marked the first time in 3 years a full crew of three manned the orbital outpost.

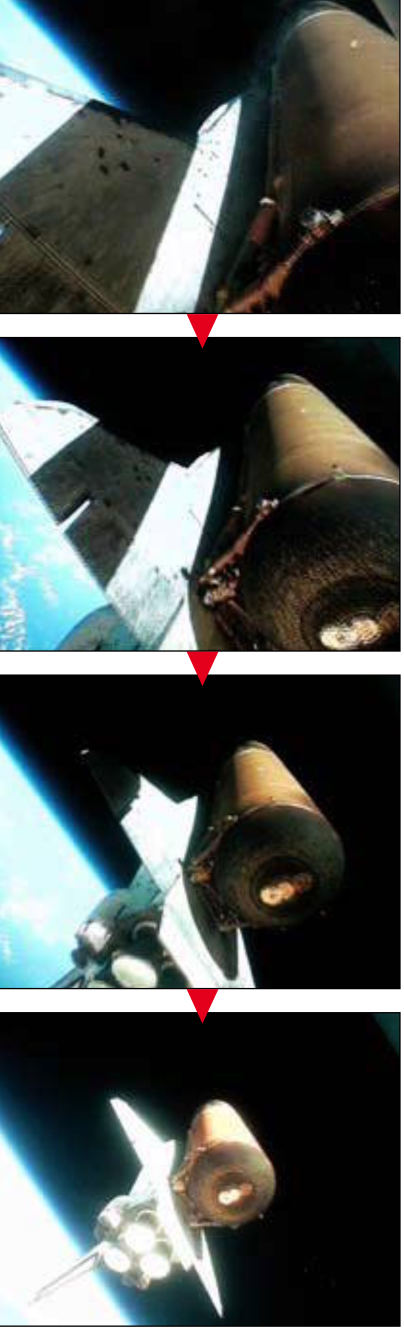
Francis Reddy *is an associate editor of* Astronomy.

Discovery docked with ISS July 6. Sellers and Fossum completed three spacewalks, two of which were spent performing critical repairs on ISS' Mobile Transporter, the railcar that moves ISS' robotic arm along the full length of its central truss. Without it, ISS construction could not resume in later flights. On July 12, Sellers and Fossum made a third spacewalk to test how well a black, peanut-butter-like substance called NOAX (non-oxide adhesive experimental) repaired pre-damaged samples of the shuttle's reinforced carbon-carbon panels. Ground tests on the panels will assess how well the material works for in-orbit repairs.

Discovery landed at Kennedy Space Center July 17. After inspecting the orbiter, Lindsey, a veteran of four shuttle flights, was impressed by his craft's lack of wear and tear. "I've never seen a vehicle that was as clean as this one is," he said.

"We're back on track," said NASA chief Michael Griffin. Asked if Discovery's success meant he'd approve a mission to the Hubble Space Telescope, Griffin said managers must complete a detailed post-flight analysis and conclude the following STS-115 mission with Atlantis successfully.

NASA considers Hubble missions riskier because a shuttle at the telescope can't reach the safe haven of ISS if problems arise in orbit. On October 31, Griffin greenlighted a fifth Hubble servicing mission, which will fly no earlier than May 2008.



A CAMERA mounted on STS-121's right Solid Rocket Booster captured Discovery heading into orbit July 4. NASA

9

Mars exploration takes a quantum leap

NASA's latest probe for exploring the Red Planet has just begun its work. Mars Reconnaissance Orbiter (MRO) entered orbit around the Red Planet March 10. In November, following months of orbital adjustment, MRO set to work in earnest.

"This mission will greatly expand our scientific understanding of Mars, pave the way for our next robotic missions later in this decade, and help us prepare for sending humans to Mars," says Doug McCuistion, director of NASA's Mars Exploration Program. By December 2008, when MRO's primary mission ends, scientists expect the probe will have returned to Earth 3,300 gigabytes of data — enough to fill more than 700 DVDs.

MRO's instruments will study Mars from the atmosphere to the planet's surface. A weather camera monitors the entire planet daily, while an infrared sounder records atmospheric temperatures and water-vapor

8

Return to Venus

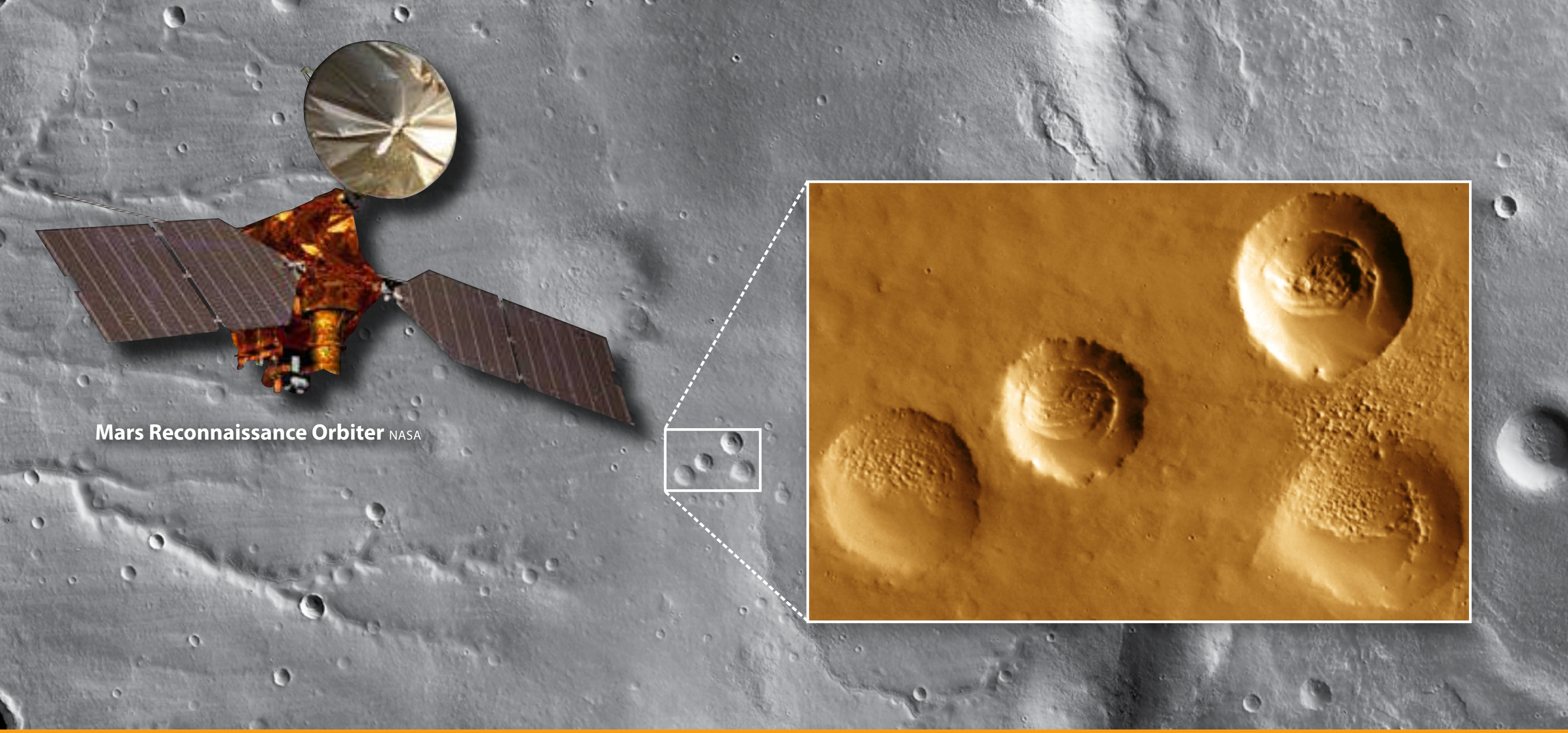
A 12-year hiatus in Venus exploration ended when the European Space Agency's Venus Express spacecraft settled into orbit around the planet April 11. Venus Express is the first probe dedicated to studying our neighbor world since NASA's radar-mapping Magellan mission ended in 1994 with a deliberate plunge into Venus' atmosphere.

Venus Express follows ESA's successful Mars Express mission, which reached the Red Planet in 2003. In fact, most of the probe's instruments were built from flight-qualified spares for two spacecraft already flying — Mars Express and Rosetta, which will arrive at Comet 67P/Churyumov-Gerasimenko in 2014.

Venus was once considered Earth's twin, based on bulk similarities. But we know now that its perpetual clouds are made of sulfuric acid, not water. Carbon dioxide makes up most of the planet's atmosphere, which is so dense it presses on the surface with more than 90 times Earth's sea-level pressure. Heat can't escape readily through the thick CO_2 atmosphere, so the surface temperature rises to a constant 870° Fahrenheit (465° Celsius). This prevents liquid water anywhere on Venus' surface. Yet scientists think Venus may once have held oceans, just like Earth. So, why are these two worlds so dissimilar now?

The primary focus of Venus Express is the planet's atmosphere. Clouds, which show up best at ultraviolet wavelengths, occur at altitudes of 30 miles (50 km) and travel around the equator in 4 days — more than 50 times faster than the planet's surface rotation. What powers this "super rotation" remains a mystery.

Venus Express has already provided the first detailed look at the planet's south polar vortex, a double-eyed atmospheric whirlpool. The probe's Visible and Infrared



MRO RETURNED **the first image from its high-resolution camera March 24. The scene reveals craters, smooth deposits, and a fault-formed ridge named Ogygis Rupes.** ***Inset:*** **These craters, imaged from MRO's high initial orbit, contain one-ninth the detail expected from the probe's final mapping orbit.** NASA/JPL/UNIVERSITY OF ARIZONA

content. The spacecraft's mineral-mapper can identify water-related deposits, such as carbonates and sulfates, in regions as small as a baseball infield. MRO's high-resolution imager, which is the most powerful camera ever sent to another planet, sees rocks the size of a small desk, and a radar instrument will probe for buried ice and water.

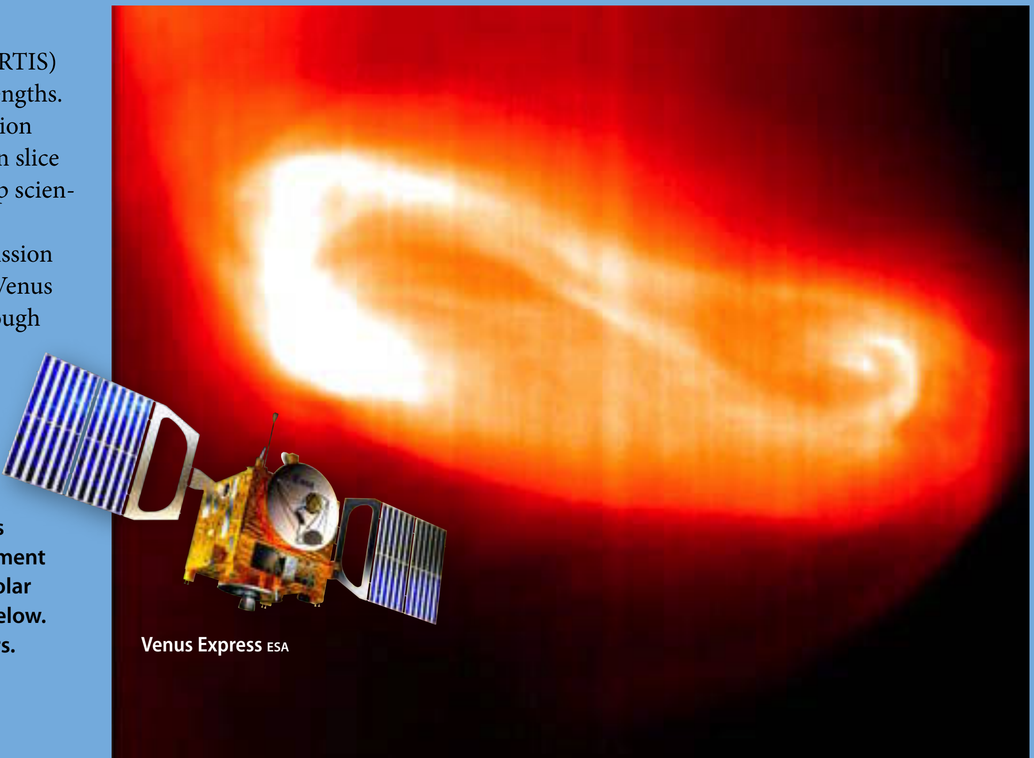
Between April and September, the $720 million mission grazed Mars' atmosphere 426 times. The maneuver, called aerobraking, reduced the farthest point of the probe's orbit from 27,000 miles (43,000 kilometers) to 684 miles (1,100 km) and reduced its orbital period from 35 hours to 127 minutes. A September 11 thruster blast put MRO in its working orbit, between 196 and 155 miles (316 and 250 km) high.

MRO joins a fleet of orbiters already studying the planet: NASA's Mars Global Surveyor and Mars Odyssey, and the European Space Agency's Mars Express. And, against all odds, both Mars Exploration Rovers are still going strong — if a little the worse for wear — almost 3 years after landing. MRO's superb vision imaged Opportunity at Victoria Crater's rim October 3.

The torrent of data from MRO will bridge two views of Mars — the global picture assembled from previous orbiters and the detailed, ground-level image the rovers provide. Judging how the scientific portrait of Mars has changed in the last few years, we can expect more surprises.

Thermal Imaging Spectrometer (VIRTIS) can operate at many infrared wavelengths. Because each wavelength sees emission from a different altitude, VIRTIS can slice through Venus' atmosphere and help scientists model its structure.

The probe's primary mapping mission will last about 500 Earth days, or 2 Venus years, but Venus Express carries enough fuel to maintain its polar orbit twice this long. Scientists hope this will be enough time to tease out some of the secrets of our strange planetary neighbor.

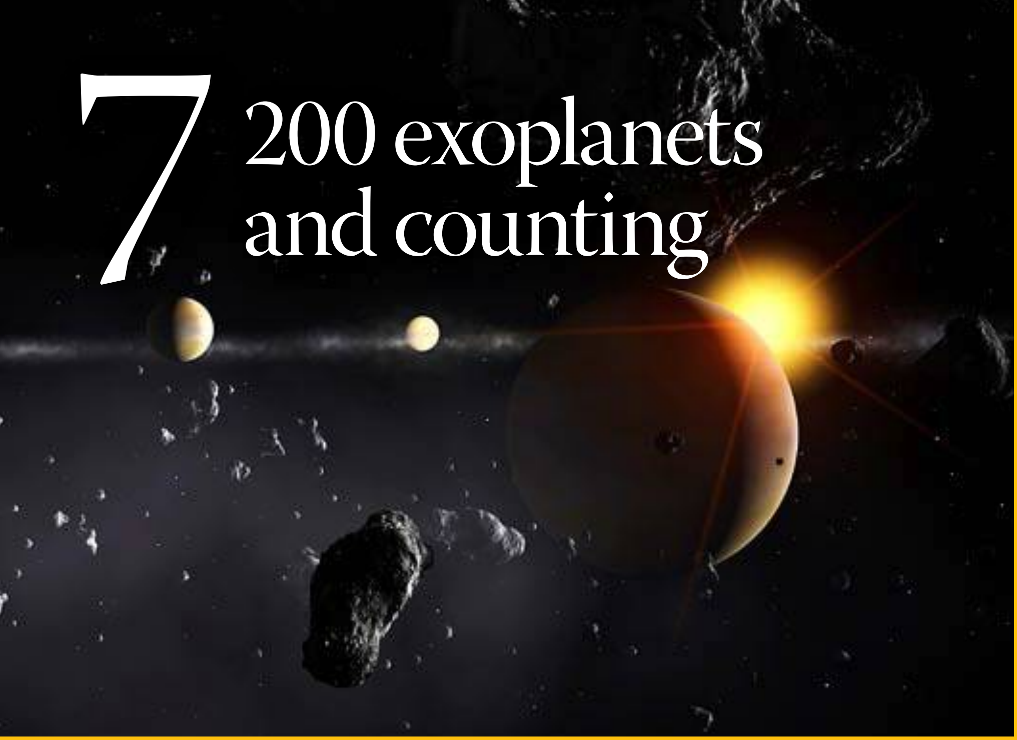


AS VENUS EXPRESS **completed its first orbit in April, its VIRTIS instrument peered into the two-eyed south polar vortex 40,000 miles (64,000 km) below. Brighter colors reveal deeper layers.**

ESA/MPS, KATLENBURG-LINDAU, GERMANY

7

200 exoplanets and counting



A TRIO of Neptune-mass planets interacts with a possible asteroid belt around the star HD 69830 in this illustration. The star lies 42 light-years away in Puppis. ESO

In late July, astronomers announced a handful of discoveries that pushed the known number of planets orbiting stars other than the Sun over the 200 mark. The southern star Mu Arae joined 55 Cancri in an exclusive club: They're the only stars other than the Sun known to harbor at least four planets. The year also brought confirmation of a 2.9-Jupiter-mass planet around Gemini's bright star Pollux.

In May, Swiss astronomers announced that three Neptune-mass planets orbit the Sun-like star HD 69830, located 42 light-years away in Puppis. The three roughly equal-mass planets impart a slight wobble to the star, which sensitive spectral measurements revealed. The planets have minimum masses between 10 and 18 times that of Earth — similar to Uranus and Neptune (14.5 and 17.1 Earth-masses, respectively). The new worlds orbit their star in just 8.67, 31.6, and 197 days.

Astronomers believe the innermost planet is probably rocky, while the outermost world is the lowest-mass planet to reside in a star's so-called habitable zone, where liquid water can exist at the surface of rocky or icy bodies. In 2005, NASA's Spitzer Space Telescope detected large amounts of warm dust around the star — possibly indicating the presence of a massive asteroid belt.

"This is hot stuff," says Alan Boss, a theorist at the Carnegie Institution of Washington. Finding a system with three "super-Earths" around a star slightly less massive than the Sun "makes the case for there being many earthlike planets out there all the more compelling."

But last January, astronomers using an observational technique called microlensing announced the smallest, most distant planet yet around a normal star. Microlensing spots planets through their gravitational effect on background starlight. The new world, called OGLE-2005-BLG-390Lb, orbits a cool M-dwarf star 21,000 light-years away in Sagittarius and is just 5.5 times Earth's mass. Scientists say a gas-giant planet this small just couldn't hold together, so they think the new world is a mixture of ice and rock.

"This finding means that Earth-mass planets are not that uncommon," explains Kailash Sahu of Baltimore's Space Telescope Science Institute and a member of the discovery team. "If we found one, there must be more."

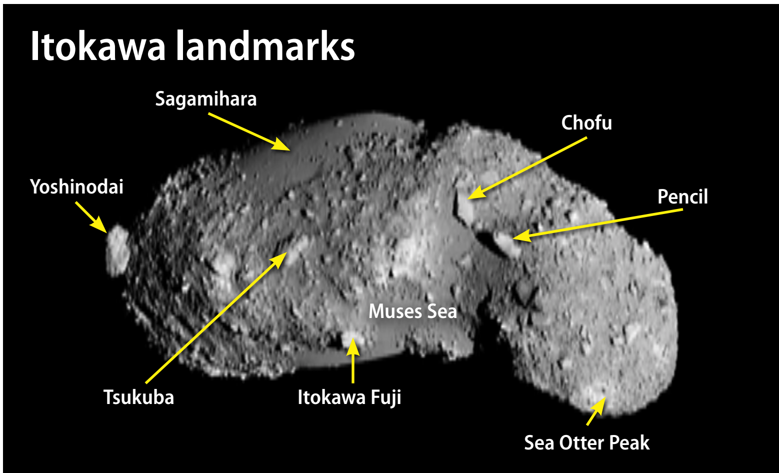
In October, a team led by Sahu announced a bevy of planetary candidates found in Baade's Window, a dense star field in Sagittarius. Using the Hubble Space Telescope, the team identified 16 stars that dim in a way that suggests planets pass in front of them. For two of these stars, spectral measurements confirm the presence of planetary-mass objects.

5

Hayabusa's asteroid odyssey

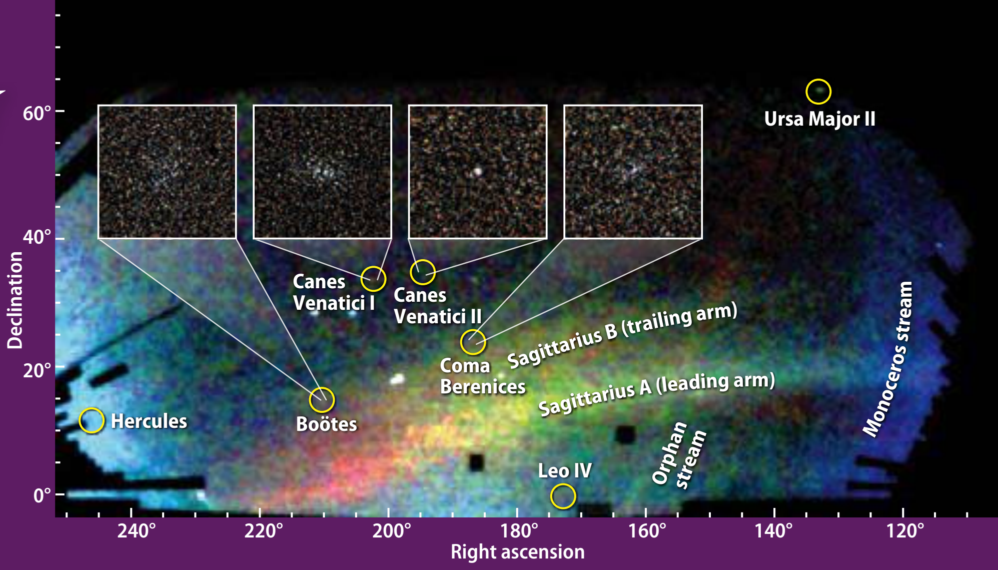
Hayabusa, Japan's mission to asteroid 25143 Itokawa, took many in the planetary science community by surprise. Launched May 9, 2003, Hayabusa ("falcon") cruised through space using its xenon-fueled ion drive until, on September 12, 2005, it took up position next to the asteroid and flew in formation with it. The ambitious mission aimed to be the first spacecraft to land on an asteroid, collect samples, and return them to Earth.

Before Hayabusa's cameras returned their first close-up images, scientists assumed small near-Earth asteroids would have surfaces



ASTEROID 25143 **Itokawa has a surface strewn with giant boulders. Yoshinodai, the largest rock, measures 160 by 72 feet (50 by 22 meters) and rises 56 feet (17m) above the surface. Gravel, not dust, covers smooth areas like Muses Sea and Sagamihara.** JAXA

6 Milky Way satellites multiply



BACKGROUND STRUCTURE formed as the Milky Way Galaxy tore apart small companion galaxies. Astronomers think the Sagittarius stream's A and B sections show the trail wraps over more than one full orbit. Circles mark the newly identified dwarf galaxies.

Astronomers at Cambridge University in England discovered seven new satellite galaxies orbiting the Milky Way. Vasily Belokurov, Daniel Zucker, and their colleagues used Sloan Digital Sky Survey (SDSS) data spanning nearly one-quarter of the sky to create the clearest-ever view of stars streaming near the Milky Way's north pole. When they eliminated red, nearby stars, so many crisscrossing trails appeared that the team dubbed the area the "Field of Streams."

Star streams form as the Milky Way's tides slowly shred satellite galaxies and globular star clusters. Debris drifts out along the orbit of the ruptured system. In May, the astronomers announced two new dwarf galaxies: Boötes and Canes Venatici, which lie 196,000 and 720,000 light-years away, respectively.

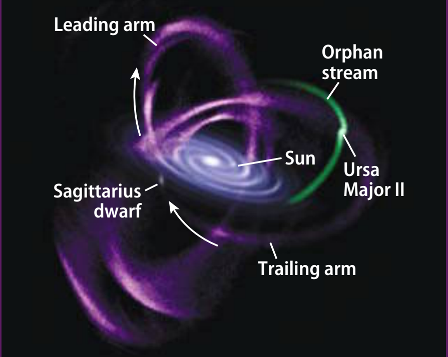
Are they galaxies or overgrown globular clusters? "Boötes, the smaller of the two, is 10 times the size of a large globular cluster, and Canes Venatici is more than 2 times larger than Boötes," Zucker explains. Both systems seem to reside within their own massive dark-matter halos.

The first known Milky Way satellites were the Large and Small Magellanic Clouds in the southern sky. Between 1937 and 1994, astronomers found nine more dwarf galaxies orbiting our own. The Cambridge team's 2006 Field of Streams study nearly doubled this number.

The Field's most prominent feature is an enormous arching trail created by the Sagittarius dwarf galaxy, discovered in 1994. Sagittarius is being ripped apart as it orbits the Milky Way. Researchers have mapped its starry stream across the sky, but the SDSS data revealed a new detail. "The stream appears forked," says Belokurov. "We are seeing different wraps superimposed on the sky as the stream goes around the galaxy 2 or 3 times."

The researchers also found a new stream that spans more than 70° of sky. They originally dubbed it the Orphan stream because they couldn't identify its source. But Belokurov now thinks it's formed by the newfound Ursa Major II dwarf, which lies within the trail. The SDSS Field of Streams provides a dramatic window into the Milky Way's continuing evolution.

The Milky Way's starry streams



OUR GALAXY'S TIDES unravel the Sagittarius and Ursa Major II dwarfs.

VASILY BELOKUROV, MICHAEL FELLHAUER/IOA, CAMBRIDGE

---

showing little geological variety. Close-up views of other near-Earth objects showed cratered surfaces coated with a thick blanket of fine soil — rock dust pulverized by eons of impacts.

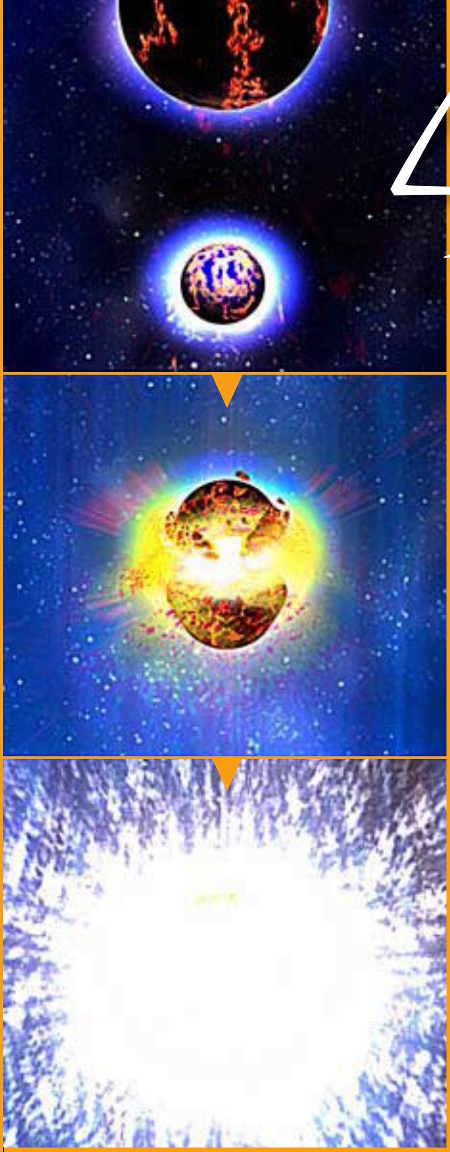
But Itokawa showed no obvious impact craters. And images of house-sized boulders, towering rock splinters, and smooth, apparently dusty, regions quickly overturned the idea that small bodies must be geologically dull.

Scientists think Itokawa is a "rubble-pile" asteroid — a loose collection of fractured rock. They speculate Itokawa's peculiar "sea otter" shape may have formed when two smaller rocks collided and fused into the 1,750-foot-wide (535m) asteroid. A smooth area, which mission scientists dubbed Muses Sea in a nod to Hayabusa's pre-launch designation (MUSES-C), may mark the area of contact. Although Muses Sea and other flat areas look like dusty plains, they're actually covered by gravel-sized stones.

Although Hayabusa twice touched down on the asteroid with the intent of collecting samples, controllers at the Japanese Aerospace Exploration Agency (JAXA) can't confirm the craft acquired any. A litany of woes followed the last sampling attempt November 25, 2005, including a power failure, lost data, thruster-fuel leaks, loss of attitude control, and persistent communication problems. By the end of May, though, JAXA engineers were communicating regularly with the spacecraft. They'll try to bring Hayabusa back to Earth by June 2010.

Seven papers in the June 2 issue of *Science* summarized the mission's findings. "Hayabusa has been a stunning success both for asteroid science and for deep space concept testing," wrote Erik Asphaug, an asteroid expert at the University of California, Santa Cruz, in an accompanying commentary. "This is an exhilarating first test of surface operations on an asteroid."

JAXA scientists expect to release and recover their falcon's sample-return capsule when Hayabusa returns home, if only to test how well the technology works. And, who knows? Against all odds, a fragment of Itokawa may have come along for the ride.



ORBITING neutron stars spiral toward each other and eventually collide, creating a short GRB. Astronomers think most short GRBs form this way. NASA/DANA BERRY

4

Crashing neutron stars make short GRBs

First detected by satellite in 1967, the brief but powerful blasts of high-energy radiation known as gamma-ray bursts (GRBs) offered astronomers as much promise as they did puzzlement. In 2003, scientists cemented a link between bursts longer than 2 seconds and massive stars exploding as supernovae.

Shorter bursts, however, remained a mystery. But in the summer of 2005, NASA's Swift and High Energy Transient Explorer-2 (HETE-2) satellites pinpointed three short bursts and cracked the case wide open.

A typical short GRB lasts just 0.3 second and has 1 percent or less the energy of its longer counterpart. Gamma-ray telescopes couldn't provide accurate positions before the blast's afterglow faded. On May 9, July 9, and July 24, however, Swift and HETE-2 gave them just what they were looking for. The May 9 blast, which lasted only 50 milliseconds, marked a first-time detection of a short GRB's X-ray-emitting afterglow.

HETE-2 picked up the July 9 GRB in a star-forming dwarf galaxy, but follow-up work with NASA's Chandra X-ray Observatory and the Hubble Space Telescope ruled out the possibility of an underlying supernova.

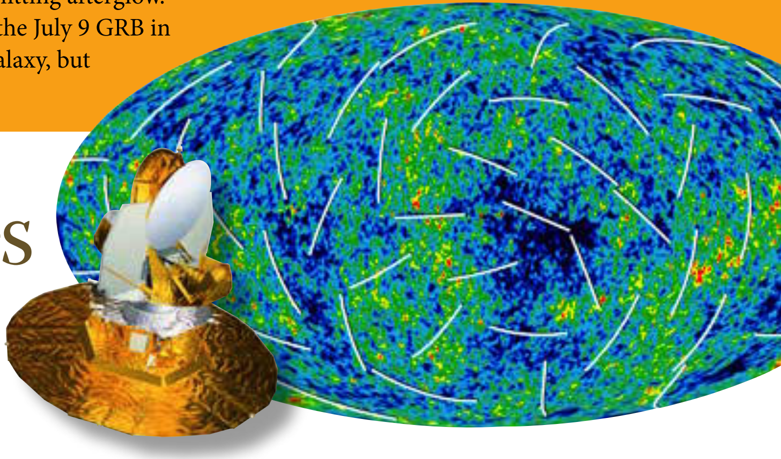
Swift detected the July 24 burst, which in 0.25 second released as much energy as the Sun does in 100 million years. Theorists suggest the source was a neutron star that ruptured as it neared a black hole. World observatories monitored the afterglow at radio, optical, and infrared wavelengths — the first pan-spectral glimpse of a short GRB. The blast came from an elliptical galaxy 3.5 billion light-years away.

Headlines trumpeted "cosmic mystery solved" following a NASA press conference in October 2005. Astronomers published papers on these events throughout 2006.

But they admit the case for mergers isn't quite closed. Swift has seen 10 other short GRBs of ambiguous origin that both mergers or massive-star collapse could explain.

Out to 200 million light-years, giant flares from supermagnetized neutron stars look just like short GRBs to Swift. And some suggest a neutron star orbiting within 1 light-minute of a normal star could steal matter and convert itself into a black hole, thereby sparking a short GRB.

There is still a long way to go, particularly for short GRBs, astronomers say. While they await more examples to study, they agree on one point: To make a short GRB, you need at least one neutron star.



2

WMAP glimpses cosmic inflation

The inflationary model of the Big Bang passed a crucial test in March. That's when scientists working on NASA's Wilkinson Microwave Anisotropy Probe (WMAP) released long-awaited data that included a view of the microwave sky's polarization. "This is the beginning of a new generation of the way cosmology will be done," says team member Lyman Page at Princeton University in New Jersey.

WMAP launched in 2001 to study the cosmic microwave background (CMB) in record detail. In 2003, the WMAP team released all-sky CMB maps that nailed down the time when atoms first formed (380,000 years after the Big Bang), the age of the universe (13.7 billion years), and the universe's contents (mysterious dark energy accounts for 74 percent; dark matter, 22 percent; and all ordinary matter, 4 percent). In addition, the team now estimates the first stars began shining some 400 million years after the Big Bang.

Since 2003, additional data allowed the team's researchers to refine their CMB temperature maps and painstakingly tease out polarization values at the level of 200 billionths of a degree Celsius. "Pretty much every technique that we brought to bear was new to the field for the polarization analysis," Page explains.

3 Tweaking the solar system

The space-science story that garnered the most headlines in 2006 had as much to do with bureaucracy as discovery. When an August meeting of the world's astronomers convened in Prague, Czech Republic, the solar system contained nine planets. By month's end, there were only eight.

Pluto was finally cast out when 424 astronomers voted August 24 on a scientific definition of "planet." It was the January 2005 find of 2003 UB$_{313}$ — better known by its TV-inspired nickname, Xena — that fast-tracked the ninth planet's demotion. Because Xena is 5-percent bigger than Pluto, either they're both planets, or neither is.

The International Astronomical Union (IAU), the official source for celestial names, put a hold on christening Xena until a scientific definition for "planet" emerged. After contentious debate, astronomers decided neither Xena nor Pluto should make the cut.

Instead, they invented a new "dwarf planet" class for objects big enough that gravity forces them into a round shape but so small their gravity fails to remove nearby objects in similar orbits. Along with Pluto and Xena, the new class includes the largest asteroid, Ceres.

Astronomers also agreed to make Pluto the prototype of a new, as-yet-unnamed class of trans-neptunian objects to which Xena also belongs.

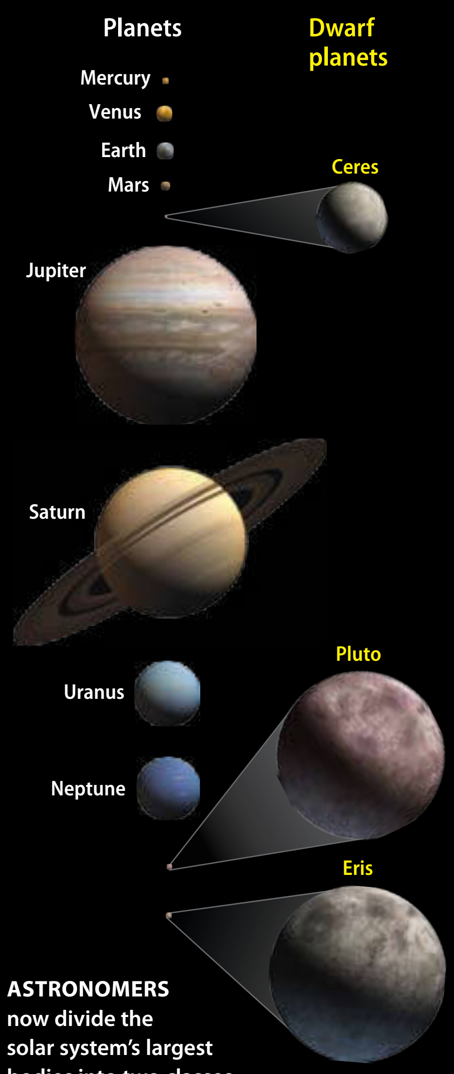
Response to the decision ranged from sighs of relief to "Honk if Pluto is still a planet" bumper stickers. Alan Stern, who heads NASA's New Horizons Pluto probe, rejects the IAU solution as unworkable, unteachable, scientifically flawed, and embarrassing.

But, lawyerly nitpicking aside, the IAU decision necessarily makes gravitational dominance an important aspect of planethood, says Caltech's Michael Brown, one of Xena's discoverers. Doing so puts Pluto in the minor leagues.

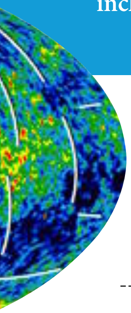
Both Pluto and Xena quickly received official numbers in the IAU's minor-planet catalog — 134340 and 136199, respectively. And, on September 13, the IAU gave Xena an official name: Eris, from a Greek goddess of discord and strife. Brown says the name of the mythological trouble-maker was "too perfect to resist." Eris' moon, Dysnomia, is the goddess' daughter and the essence of lawlessness — a reference that even preserves a link to TV's *Xena: Warrior Princess*, which starred Lucy Lawless.

While the vote ended the essentially empty debate over Pluto's status, the new definition doesn't apply to worlds outside the solar system. Astronomers may broaden and clarify it in 2009, when the IAU's General Assembly meets again.

Planets vs. dwarf planets



ASTRONOMERS now divide the solar system's largest bodies into two classes, planets and dwarf planets. The dwarf planets include Pluto, Eris, and Ceres, the largest asteroid. ASTRONOMY: ROEN KELLY



THREE YEARS of data collected by NASA's WMAP spacecraft (inset) reveal the preferred direction (white lines) of CMB emission. This, in turn, let cosmologists verify a key prediction of Big Bang inflation models. NASA/WMAP SCIENCE TEAM

The CMB microwaves become polarized, or oriented, in three ways. One involves the passage of gravitational waves through the early universe's hot plasma. It's distinct, but beyond WMAP's reach. The other type occurred twice — once when CMB microwaves scattered off the early universe's plasma, and again much later, when they ricocheted off electrons freed up when the first stars re-ionized neutral hydrogen gas.

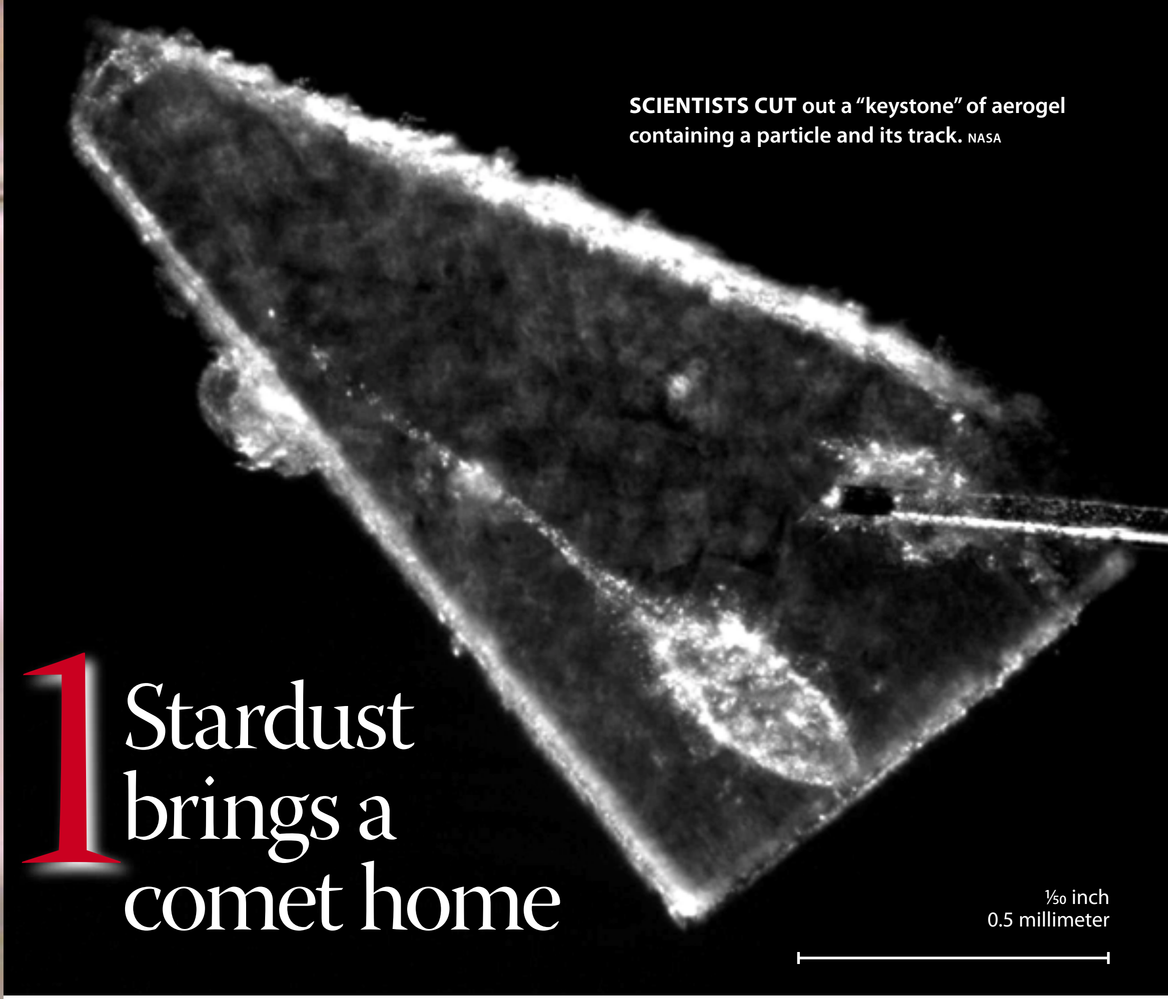
The new polarization data let cosmologists untangle two similar temperature effects, one from inflation, and the other from the first stars. "We can take it apart and say this much came from the first stars and that much came from inflation," says Johns Hopkins University's Charles Bennett, the mission's principal investigator. "We didn't actually measure the polarization from inflation," he explains. "That's still something we'd like to do."

Subtracting the effects of the first stars gives cosmologists a handle on the size of CMB fluctuations at different angular scales. "What the polarization does for us is help narrow down the range of things that could've happened in the universe," Bennett explains. Picture the CMB as a lake surface disturbed by waves of many different lengths. According to the simplest Big Bang model, the longest waves and the shortest ripples all have the same height.

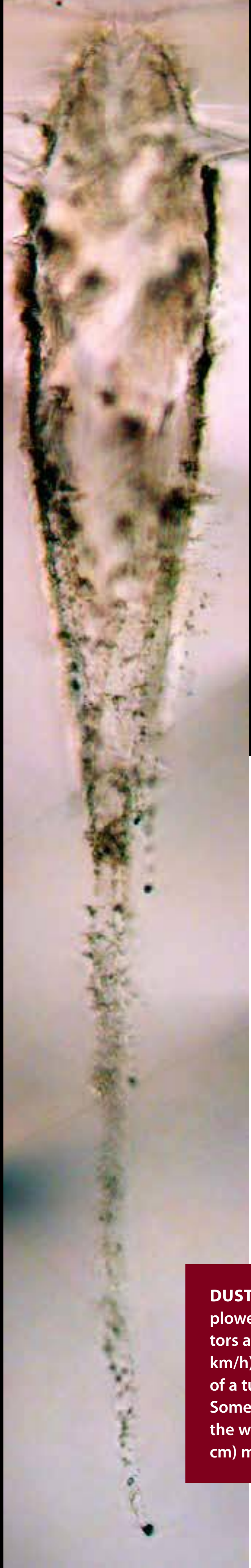
But inflation, which holds that the universe went through a hyper-fast expansion a fraction of a second after the Big Bang, predicts something slightly different. WMAP provides the first measurements precise enough to verify a predicted behavior of inflation. Better yet, the results show only the simplest inflation scenarios agree with the CMB.

"It looks like we can really get at the physics of the universe at 10^{-35} second," Page says. "That's just an amazing thing."

1 Stardust brings a comet home



SCIENTISTS CUT out a "keystone" of aerogel containing a particle and its track. NASA



DUST GRAINS from Comet Wild 2 plowed into Stardust's aerogel collectors at more than 13,000 mph (22,000 km/h). Each grain appears at the end of a turnip-like trail of melted glass. Some particles punched two-thirds of the way through the 1.2-inch-thick (3 cm) material. NASA

On January 15, NASA's Stardust mission delivered the goods. As the spacecraft cruised past Earth, it released a 101-pound (46 kilogram) capsule containing cometary dust samples captured 2 years earlier when it flew by Comet 81P/Wild 2 (pronounced "Vilt-2").

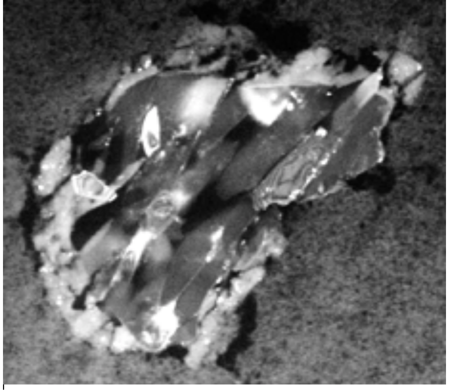
Around 2 A.M. Pacific time, the capsule hit the atmosphere moving at 28,860 mph (46,440 km/h) — the fastest reentry of any spacecraft — and blazed a meteoric trail across the western United States. Its journey ended with a safe parachute landing at the U.S. Air Force Test and Training Range southwest of Salt Lake City.

Stardust Program Manager Thomas Duxbury had just finished speaking to the press at the U.S. Army's Dugway Proving Ground in Utah when the recovery team's first images of the blackened capsule at rest on the desert floor appeared on monitors. He had last seen the craft 7 years and 2.88 billion miles (4.6 billion km) ago. There it sat, unharmed, carrying the first-ever direct samples of a comet. "I had tears in my eyes," he says.

Launched in 1999, the $200 million Stardust probe swept past Comet Wild 2 January 2, 2004. It passed 149 miles (240 km) from the icy nucleus, ensnaring dust particles blown off the comet in a glass-air substance called aerogel. When six research teams, comprising more than 200 scientists around the world, began analyzing the samples, something odd stood out immediately.

Astronomers pictured comets as forming beyond Neptune from submicron-sized interstellar dust grains that existed before the Sun took shape. "Against that," says the University of Washington's Don Brownlee, Stardust's lead researcher, "we're finding rocks up to tens of microns in size, at least some of which formed clearly in the inner part of the solar system."

They're related to the calcium-aluminum intrusions (CAIs) found in meteorites. CAIs are the oldest things in the solar system — predating other meteorite components by a few million years — and formed in the solar nebula's hottest regions. "We basically found solids that formed in the hottest possible



PARTICLES like this 2-micrometer-wide chunk of forsterite form only in high-temperature environments. What's it doing inside a comet? NASA

TECHNICIANS at the U.S. Army's Dugway Proving Ground near Salt Lake City remove Stardust's samples following the capsule's recovery. NASA

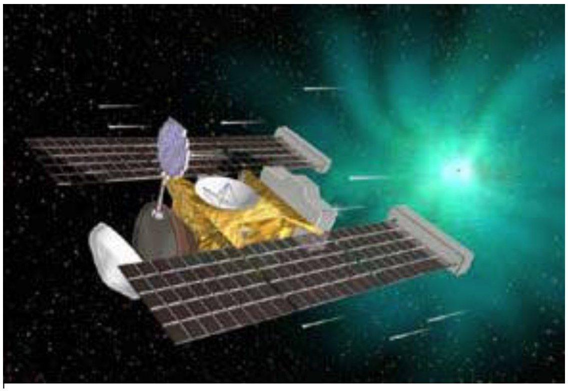
regions of the solar nebula, and we found them in the coldest possible place," Brownlee explains. "That single observation … implied there was large-scale mixing from the inner part of the solar system all the way to the outside."

"It pulled the rug out from under all the preconceived notions we had," says Donald Yeomans, a comet expert at the Jet Propulsion Laboratory in Pasadena, California. "What's going on here? Where do these particles come from?"

Some think jets blasting from the young Sun could have ejected material from the inner solar system to where comets formed. Mixing could have occurred through other processes, too. The mystery particles may even have come from other solar systems, Yeomans says. That's a possibility Stardust researchers will address by examining interstellar dust the probe collected.

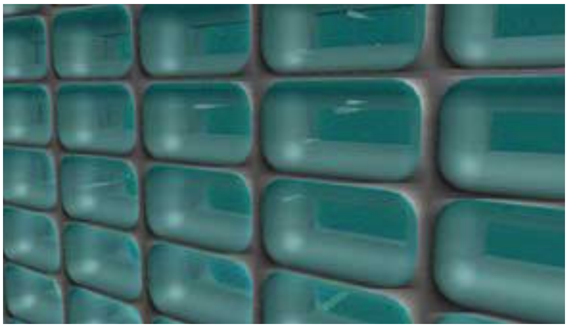
"Just finding a single piece of this stuff out there shows that, however it was done, there was a mechanism to transport materials from the innermost regions to the outermost regions," Brownlee says. "You can speculate on that forever, but actually having proof of it is something different."

STARDUST'S sample-return capsule blazed across the night sky January 15, 2006. NASA



NASA

STARDUST encountered Comet Wild 2 January 2, 2004. The probe raced past the comet's nucleus at 6 times a rifle bullet's speed.



NASA

AEROGEL CELLS slowed and captured Comet Wild 2's dust particles. The impacting dust melted trails in the glass-air substance.

ONLINE EXTRA Is there a future for Stardust? Find out at www.astronomy.com/toc.

QUICK LOOK

STORIES TO WATCH IN 2007

New Horizons, NASA's mission to Pluto, streaks past Jupiter February 28.

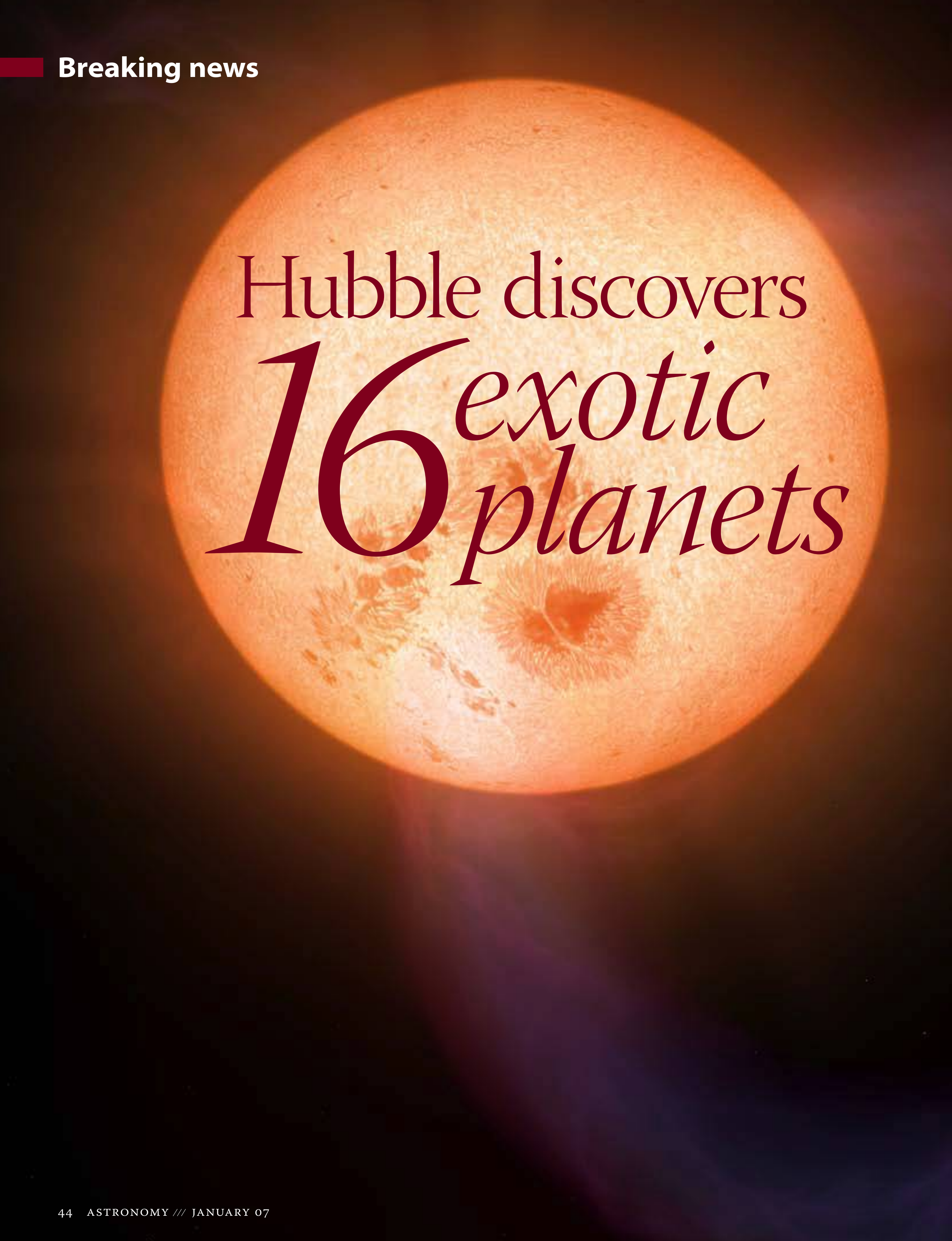
Chang'e 1, China's unmanned lunar orbiter, is scheduled for launch this April.

Jules Verne, ESA's first Automated Transfer Vehicle, is slated to blast off in May.

ESA's **PLANCK** cosmology probe and **Herschel** infrared space telescope are scheduled for launch in July.

NASA's **Cassini** spacecraft flies past Saturn's two-toned moon Iapetus September 10.

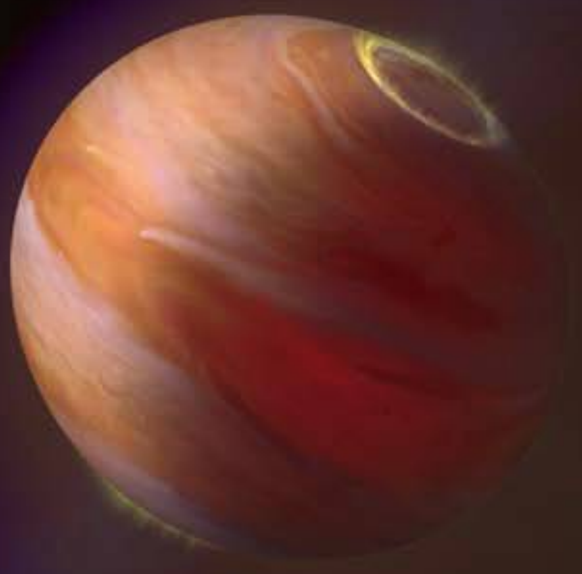
GLAST, the Gamma-Ray Large Area Telescope, is scheduled to launch October 7.



Hubble discovers 16 exotic planets

Egg-shaped planets with dazzling aurorae must be the norm for these new worlds that orbit within shouting distance of their parent stars.

/// **BY RAY VILLARD**



THIS JUPITER-SIZED PLANET orbits just 740,000 miles (1.2 million km) from its parent star and completes a circuit every 10 hours. Hubble has found 16 new "hot Jupiters" in the direction of our galaxy's center. NASA/ESA/A. SCHALLER (FOR STScI)

In the past decade, astronomers have discovered some 200 planets orbiting stars other than the Sun. Nearly half of these planets are Jupiter-sized worlds that orbit closer to their parent stars than Mercury does to our Sun. Until now, these "hot Jupiters" have been considered the most exotic worlds uncovered in the exoplanet treasure hunt.

But just when you thought exoplanets couldn't get any stranger, scientists using the Hubble Space Telescope have discovered more than a dozen planets that live on the edge. One of them cruises so close to its star, it completes an orbit in some 10 hours. The planet lies only 3 times farther from its star than the Moon does from Earth, and gravity must stretch it into an egg shape. The planet's atmosphere seethes at 3,000° Fahrenheit (1,850° Celsius).

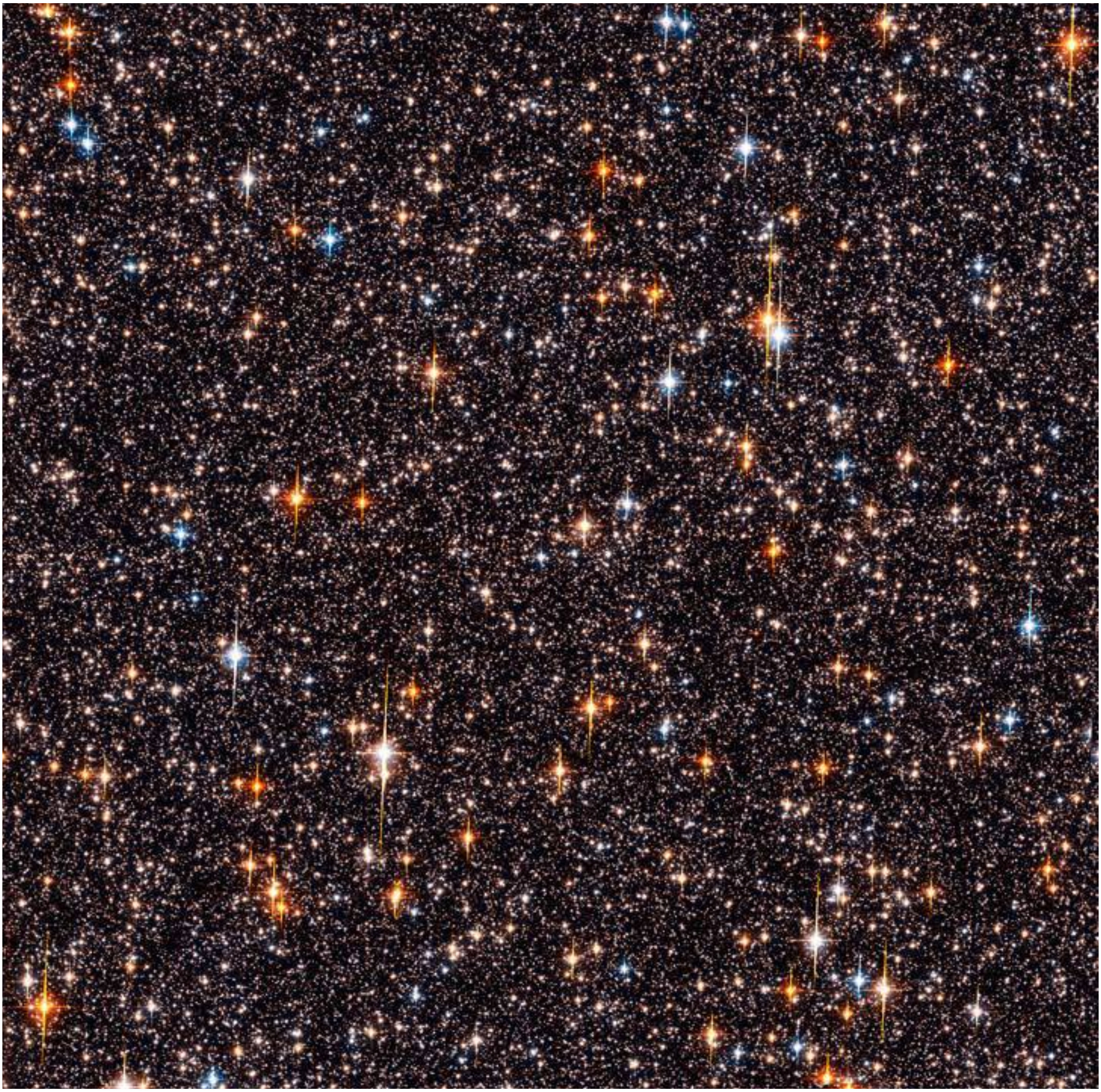
Astronomers have dubbed these new worlds ultra-short-period planets, or USPPs. Their existence provides tantalizing evidence that exoplanets can survive in environments formerly thought too hostile for planets. Equally fascinating — no similarly scorched worlds have turned up among the stars in our neighborhood. Instead, Hubble successfully looked farther and examined fainter stars than previous planet quests.

Galactic quest

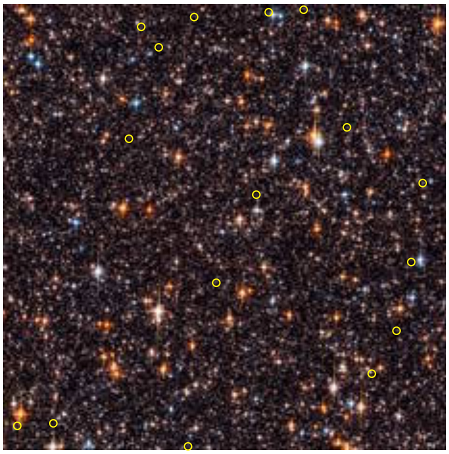
Hubble scientists found the USPPs by aiming at a pinpoint in the constellation Sagittarius that offers a keyhole peek straight into the galaxy's center. The observation, called the Sagittarius Window Eclipsing Extrasolar Planet Search (SWEEPS), monitored a rich concentration of stars over a 7-day period. Thus, SWEEPS opened a new parcel of exoplanet "discovery space."

Astronomer Kailash Sahu of Baltimore's Space Telescope Science Institute and colleagues took advantage of Hubble's keen ability to record tiny variations in starlight intensity. If a planet orbits its star inclined edge-on to Earth, the planet will pass in front of the star, or transit, once each revolution. Granted, a transiting planet doesn't block much

Frequent contributor **Ray Villard** *is the news director for the Space Telescope Science Institute in Baltimore.*



NASA/ESA/K. SAHU (STScI) AND THE SWEEPS SCIENCE TEAM (BOTH IMAGES THIS PAGE)



▲ SOME 245,000 STARS populate the SWEEPS field. Hubble took approximately 520 images of the field over a 7-day period, and astronomers discovered planets orbiting 16 of these stars.

◀ THE 16 STARS WITH PLANETS lie inside the circles in this view of the SWEEPS field. Even with Hubble's sharp optics, most of these stars appear as faint blips.

light, but Hubble can measure 1-percent changes in star brightness.

The previous record-holders for deep-sky exoplanet searches came from programs that use gravitational microlensing. When a star and its accompanying planet pass in front of a more distant star, the background star's light gets amplified. Einstein predicted this effect because the foreground object's gravitational field warps space. If the geometry is right, the signature of a planetary companion is embedded in the background star's light curve. This microlensing technique has revealed planets up to 20,000 light-years from Earth.

But the Hubble observations stretch to one-quarter the way across the galaxy, practically to the Milky Way's core. Unlike microlensing searches, which provide only fleeting detections and no chance for follow-up observations, transit detections allow astronomers to calculate a planet's orbit as well as its distance from its star.

The challenge of observing transiting exoplanets is that planetary orbits rarely align edge-on to Earth. Only 1 out of 100 exoplanets should be oriented this way. Therefore, Sahu's team had to look at a lot of stars at once. The most efficient way to accomplish this was to look at the region of sky with the densest collection of stars — the galactic center.

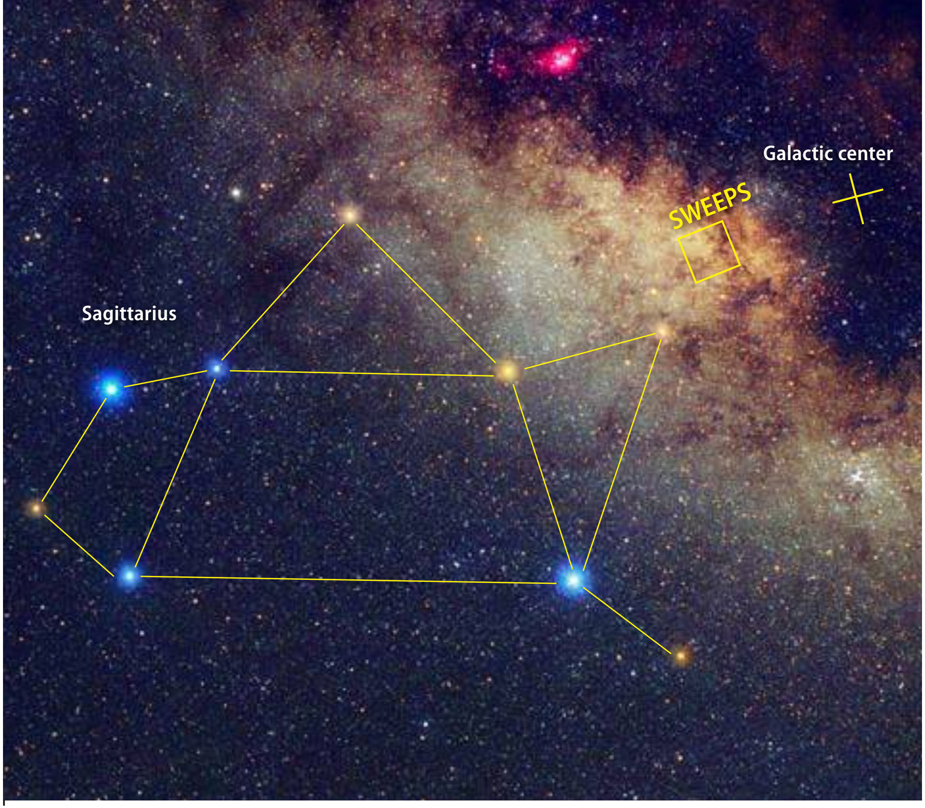
Although foreground dust obscures large swaths of the galactic plane, certain "windows" offer astronomers a clear view into the galactic bulge. One such rich starry region — located 4° from the galactic center and known as Baade's Window — lies near Sagittarius' border with Scorpius.

From February 22 to 29, 2004, Hubble's Advanced Camera for Surveys took 519 pictures of the 246,793 stars in this Sagittarius window. Once researchers assembled all the images, the team processed the data to identify any changes in stellar brightness in the crowded field.

More than two-thirds of the stars were bright enough for the team to search for brightness dips caused by transiting planets. Out of that sample, the astronomers found 1,100 stars varied during the 7 days of observation. The team also identified and eliminated 165 short-period eclipsing binary stars they found in the field.

However, 16 of the stars have unique light curves that fit model predictions of what a planetary-mass companion passing in front of a star should look like. The team was careful to rule out stellar transits that could masquerade as planetary-mass companions. These could arise in a stellar binary undergoing a grazing eclipse, an eclipsing stellar binary in which the light drop is mitigated by the presence of a third star in the system, or a transit by a brown dwarf or low-mass star having the diameter of a jovian planet.

Nevertheless, the team cautiously insists on calling these 16 objects "candidate planets" because the transit technique by itself does not yield the companion object's mass. From the amount of dimming Hubble observed during the planetary transits, the team can say only that the companions must have diameters between 0.8 and 1.4 times that of Jupiter.



BILL AND SALLY FLETCHER

THE SWEEPS REGION examined by Hubble lies in Sagittarius, just 4° from the galaxy's center.

To get an orbiting object's mass, astronomers must measure precisely the star's radial velocity. The unseen planet's gravity tugs on its parent star, inducing a slight wobble in the star's motion that repeats every orbit. If the planet's orbit lies edge-on to our line of sight, the planet's gravity will cause the star to move toward and away from us. Astronomers then can measure this slight wobble by observing the Doppler shift exhibited in the star's spectrum.

Unfortunately, all but two of the 16 planetary candidate stars are too dim for even the biggest telescopes to gather the photons necessary for a spectrograph to reveal a Doppler shift. In addition, the crowded field makes pinpointing most of the target stars close to impossible.

In June 2004, the astronomers observed these two stars spectroscopically with the European Southern Observatory's 8-meter Very Large Telescope in Chile. Radial-velocity measurements showed one of the planets has a mass below the detection limit of 3.8 Jupiter-masses. The other candidate contains roughly 9.7 Jupiter-masses. This falls below the cutoff mass for a brown dwarf — a substellar object that forms like a star but doesn't have enough mass to initiate nuclear fusion — of 13 Jupiter-masses, so it, too, qualifies as a planet.

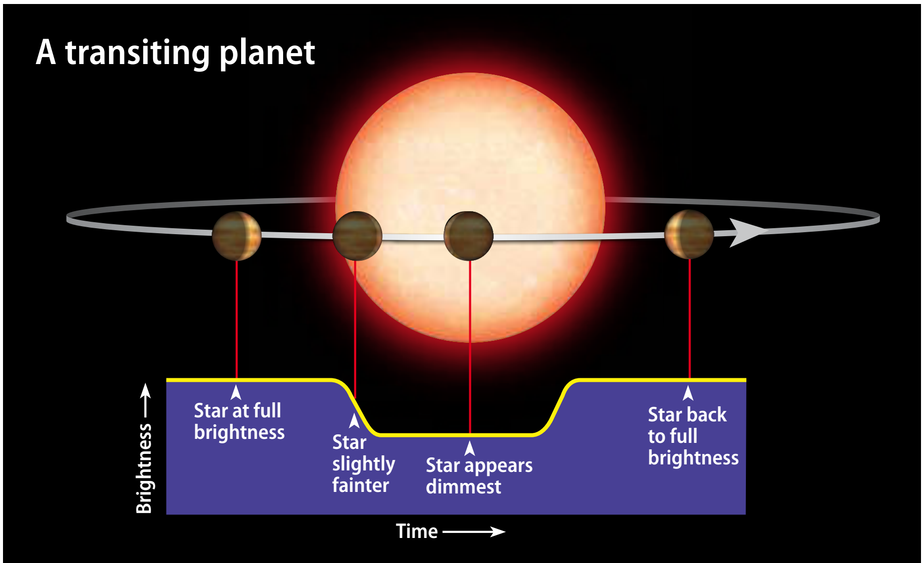
The Hubble team was restricted to looking for hot Jupiters because the observations lasted only a few days. Prior to SWEEPS, astronomers had discovered six transiting planets in our local stellar neighborhood. All six orbit stars containing at least 78 percent of the Sun's mass. Based on the local census of transiting hot Jupiters, the Hubble astronomers predicted they might find a few dozen candidate planets in the crowded SWEEPS field.

Ultra-short-period planets

What they didn't expect was that five of the new exoplanets would have extraordinarily short orbital periods, each breaking the 1.2-day record for the fastest orbit among nearby transiting planets. Prior to the SWEEPS survey, the 10 known transiting planets had orbital periods between 1.2 and 4.0 days and possessed about 0.3 to 1.5 Jupiter-masses.

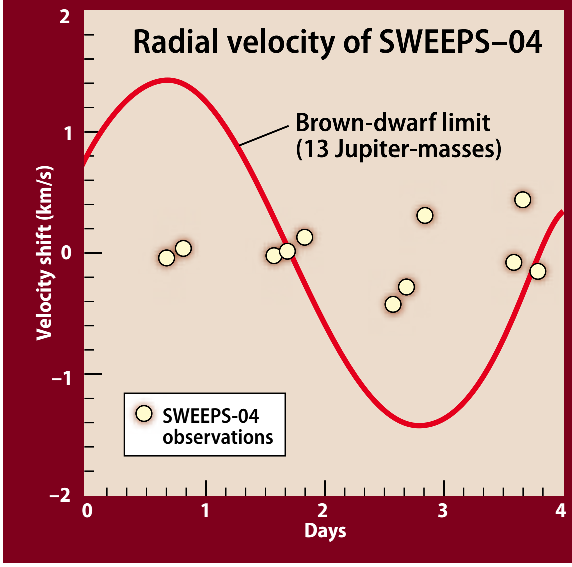
These five new worlds truly are extreme. Immense tidal forces stretch each USPP into an egg shape. Only a few hundred thousand miles above the red dwarf star's photosphere, the closest-orbiting of the star-hugging planets must have at least 1.6 times the mass of Jupiter. Otherwise, the star's gravitational muscle would pull the planet apart. Flares erupting off the star brush the planet like a dragon's breath.

The planet likely has a powerful magnetic field that traps charged particles flowing from the star. This would create glowing auroral rings around the planet's magnetic poles. If the magnetic coupling



HUBBLE DETECTED THE EXOPLANETS by looking for transits. If a planet's orbit lies edge-on to our line of sight, once each orbit the star's brightness will dim slightly as the planet blocks a bit of the star from view. *ASTRONOMY:* ROEN KELLY

NASA/ESA/K. SAHU (STScI) AND THE SWEEPS SCIENCE TEAM



▲ **THE STAR SWEEPS–04** (circle) may look faint, but it's one of only two with planets bright enough to observe spectroscopically.

◀ **THE RADIAL VELOCITY** of SWEEPS–04 shows just a slight wobble — much too small to be caused by a brown dwarf — so it must be a planet. *ASTRONOMY:* ROEN KELLY, FROM ESO DATA

between Jupiter and Io is any example, then a pair of magnetic flux tubes probably stretches between the star and planet like a Slinky. This would further enhance the host star's activity, triggering powerful flares and hot spots in its chromosphere.

An intense stellar wind would create a bow shock around the planet. A steady stream of gases must bleed off the planet's super-heated atmosphere and streak into space, creating the look of an over-sized comet. Nevertheless, the planet has survived possibly as long as 10 billion years, so it can't be losing mass at an appreciable rate.

Seen from the roiling cloud tops of this planet, the red dwarf would span nearly 30°. Its blinding disk would extend from the planet's horizon one-third of the way to the zenith. The football-shaped planet is almost certainly tidally locked to the red dwarf, with one hemisphere permanently aimed toward the star. Violent convection cells would carry searing atmospheric gases back to the planet's perpetually dark side.

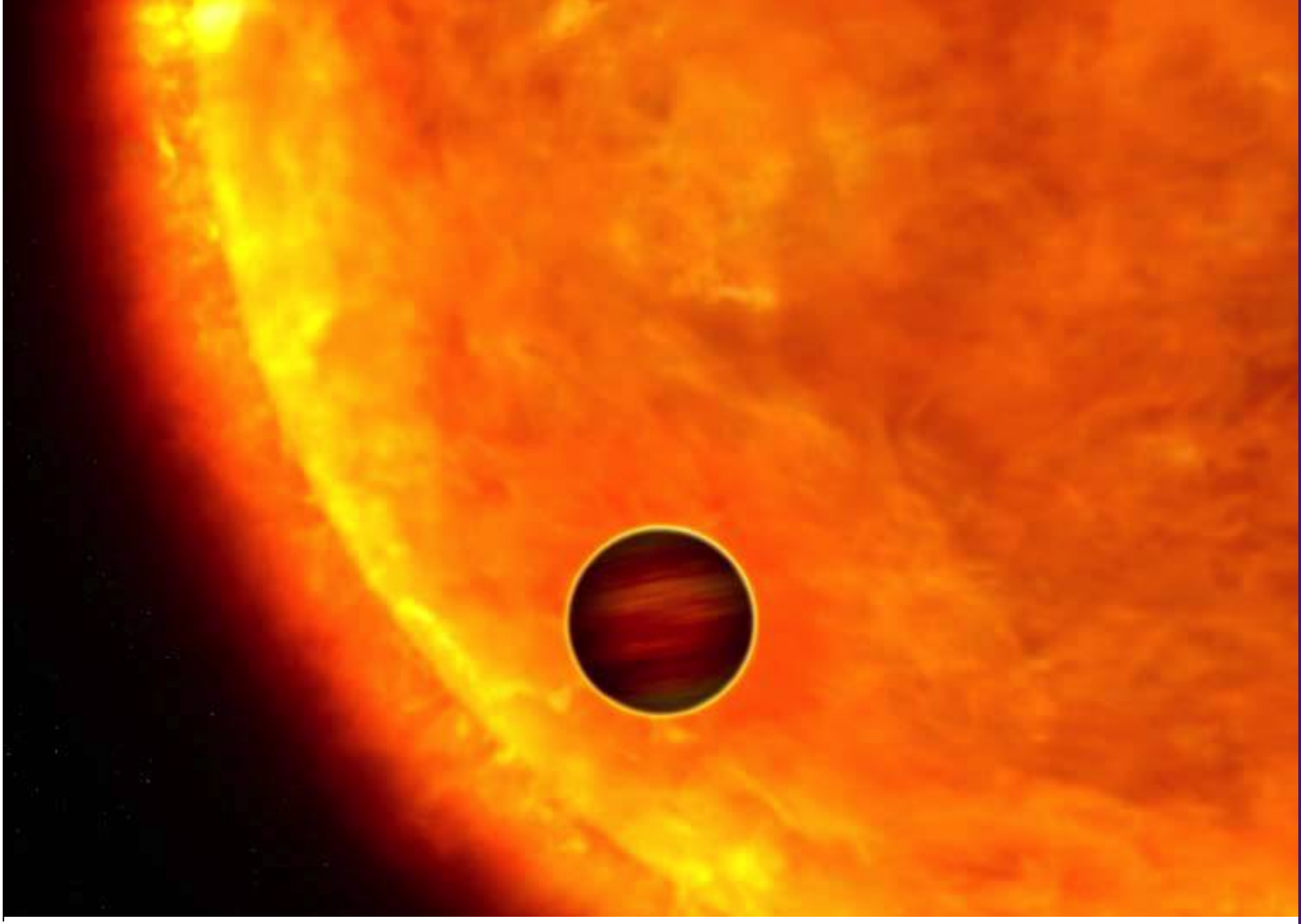
The planet must also raise tides on the red dwarf, presumably creating a hot spot on the star that would track with the planet like a searchlight. The planet lies too deep within the star's gravitational potential for it to retain any moons or dusty rings.

The fact that USPPs exist at all presents another quandary for planet-hunters. Such close-in planets around stars like our Sun or hotter would evaporate away. This means USPPs must all orbit red dwarfs, whose surface temperatures are but a fraction of the Sun's. This explains why astronomers have not detected any USPPs among the approximately 200 exoplanets found within a few hundred light-years of Earth.

Most of the nearby stars being studied shine as bright or brighter than the Sun. The local surveys are biased toward relatively bright stars because researchers then can use high-resolution spectroscopy to measure the subtle stellar wobble induced by the pull of a planetary companion. Only recently have techniques improved to the point where scientists can analyze the radial velocities of nearby red dwarf stars.

Planet migration

The new Hubble planets certainly could not have formed so close to their stars. How did they get there? A planet with the mass of Jupiter needs to form beyond a star's so-called frost line — the distance at which ices and other volatile substances in a



A JUPITER-MASS PLANET **transits its parent star, which dims the star's light slightly. Hubble has detected 16 new planets lying near the galaxy's center using this technique.** NASA/ESA/G. BACON (STScI)

circumstellar disk can remain intact and be incorporated into a planet. For our Sun, the frost line lies roughly 400 million miles (600 million kilometers) out, between the orbits of Mars and Jupiter. Inside the frost line, only heavier elements like carbon, oxygen, silicon, nickel, and iron are available to build rocky terrestrial planets. Beyond the frost line, large quantities of hydrogen and helium, as well as volatile ices, are on hand to build giant planets.

That's why theorists began to look harder at the idea of planet migration when the first hot Jupiters were discovered in 1995. The hypothesis is that these gas-giant planets had to form far from their host stars and then somehow migrate closer in. A thick disk surrounding a star rich in heavy elements may provide enough drag to cause a planet to lose orbital energy through friction, shrinking its orbit. The Hubble SWEEPS observation bolsters this idea because all the candidate stars have an abundance of heavier elements, so, conceivably, they once had thick circumstellar disks.

But what stops a migrating planet from simply falling into the star? A star's magnetic field and stellar winds carve out a gap in the middle of the circumstellar disk, like the hole in an old-fashioned phonograph record. The hole around a red dwarf presumably would be smaller than that around a hotter star because the lower levels of radiation and stellar wind would be less efficient in excavating material near the disk's inner edge. The smaller gap means there's a longer highway for a planet to continue spiraling in. When it reaches a precipice precariously close to its parent star, where the disk material runs out, migration abruptly stops.

The Hubble observations have served as a trailblazer for NASA's Kepler planet-hunting mission, scheduled for launch in 2008. Kepler's telescope won't search as far away as SWEEPS. Instead, it will probe the galaxy in the direction of the constellation Cygnus, looking for transiting exoplanets out to roughly 2,000 light-years.

Kepler's goal is to find earthlike planets, those with masses similar to our own world in far more leisurely, yearlong orbits around solar-type stars. Kepler astronomers will need to observe stars for at least several years to confirm the presence of an earth-like planet because an individual planet transits only once a year or so.

Like the SWEEPS survey, many of Kepler's detections will be relegated to planet-candidate status until astronomers can take precise radial-velocity measurements. In the case of the SWEEPS planets, the James Webb Space Telescope, scheduled for launch in 2013, may be able to perform follow-up observations that will nail down the masses of many of the candidate planets.

As the farthest survey into our galaxy, the SWEEPS observation provides compelling evidence that the Milky Way could harbor about 6 billion Jupiter-like planets. Considering that exoplanet astronomy is barely a decade old, this is an amazing conclusion to reach so soon, and it's all thanks to Hubble's powerful galaxy-probing capabilities. The SWEEPS observation has opened up a vast new arena for us to ponder the variety of worlds across the galaxy.

Surprising sizes

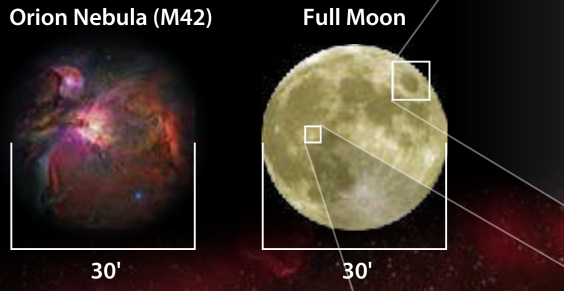
Is the Orion Nebula as big as the Moon?

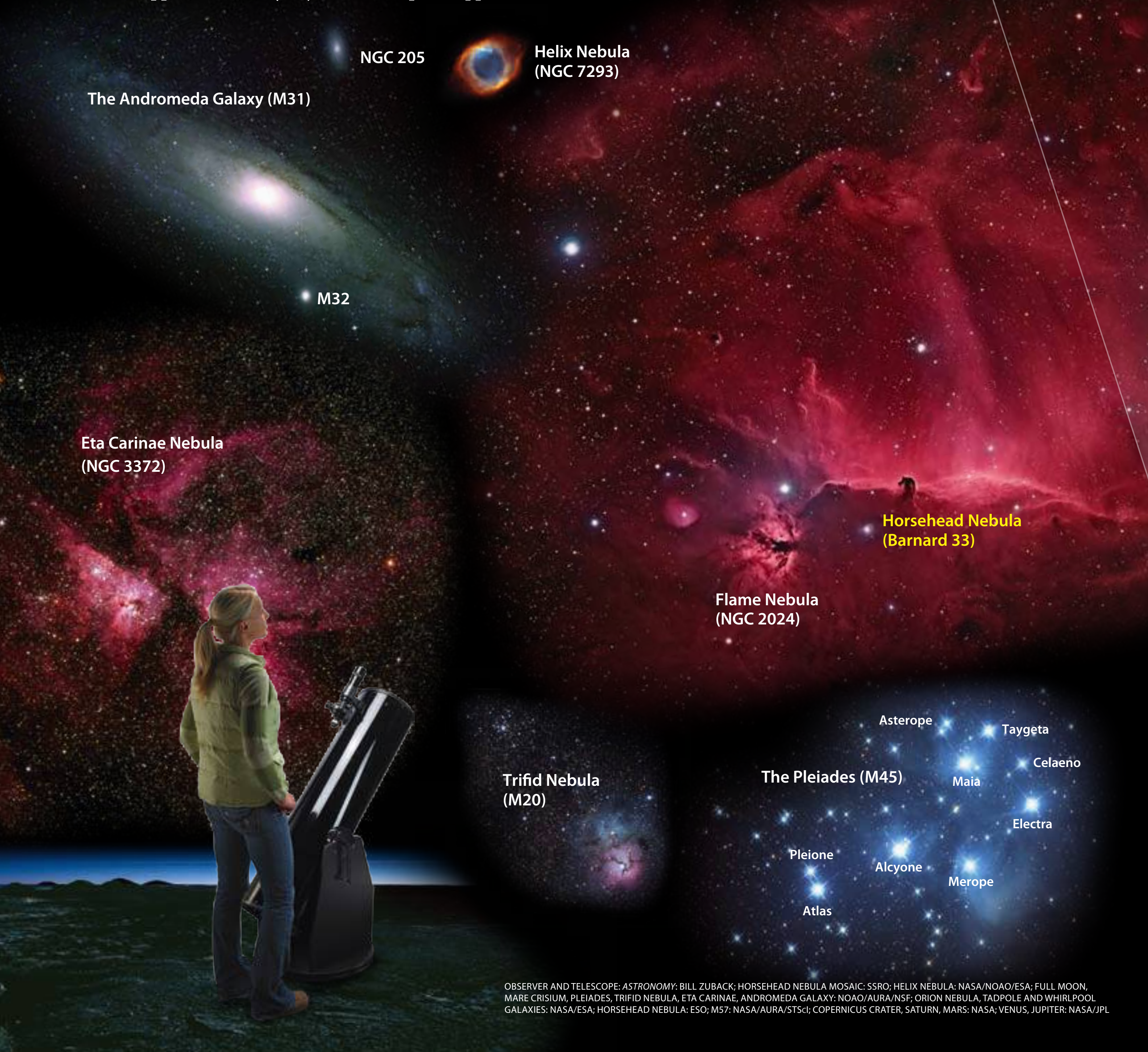
The Moon's apparent size provides a yardstick for comparing the sky's best-known targets.

/// BY FRANCIS REDDY

You wouldn't think there'd be much to compare between the Moon and the famous Orion Nebula (M42), a giant cloud of gas and dust where stars are born. Yet, from our perspective on Earth, the two objects span the same size of celestial real estate — half a degree (30', or 1,800").

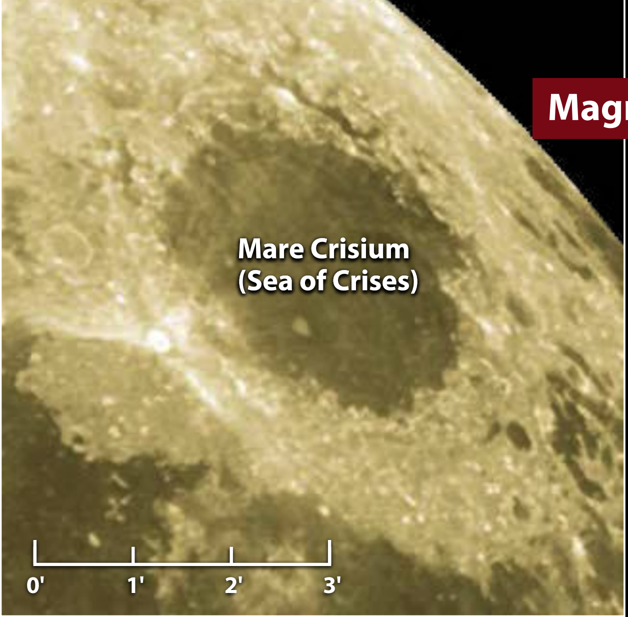
The Full Moon so dominates our view, we can easily imagine it's the largest object visible without a telescope. Yet, the Pleiades (M45) star cluster, the Andromeda Galaxy (M31), and the vast Eta Carinae Nebula all dwarf the Moon's apparent size. Sky objects in each panel appear at the same scale.


Orion Nebula (M42)
Full Moon
30'
30'


NGC 205
Helix Nebula
(NGC 7293)
The Andromeda Galaxy (M31)
M32
Eta Carinae Nebula
(NGC 3372)
Horsehead Nebula
(Barnard 33)
Flame Nebula
(NGC 2024)
Trifid Nebula
(M20)
The Pleiades (M45)
Asterope
Taygeta
Celaeno
Maia
Electra
Pleione
Alcyone
Merope
Atlas

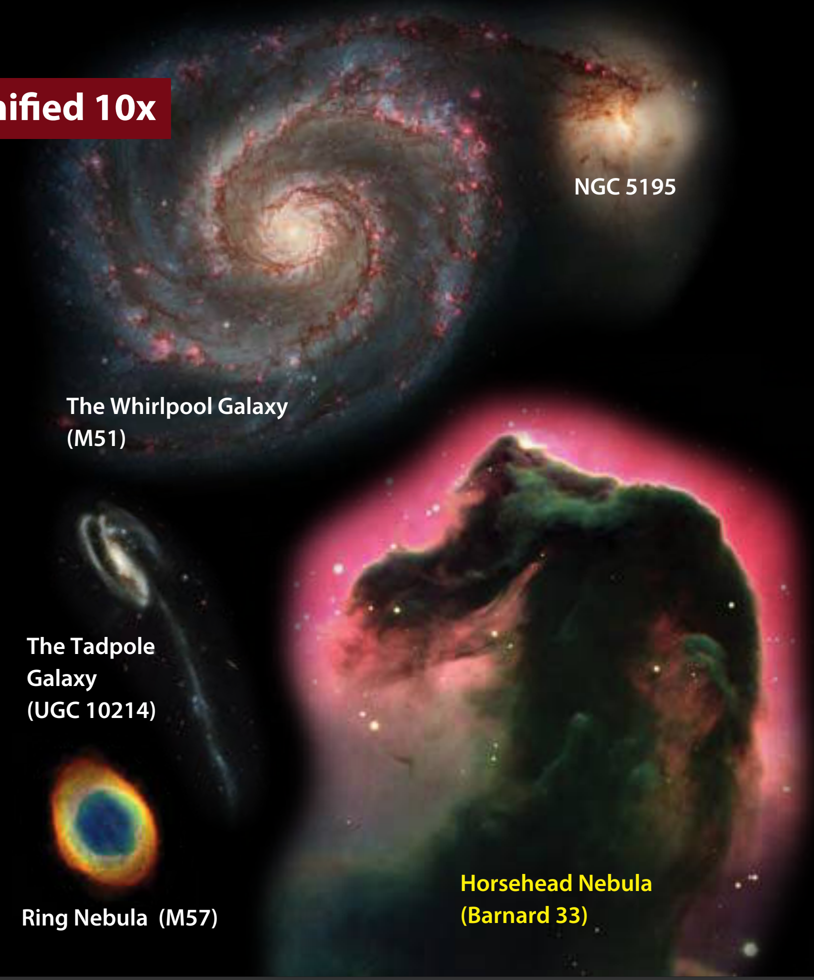
OBSERVER AND TELESCOPE: *ASTRONOMY*: BILL ZUBACK; HORSEHEAD NEBULA MOSAIC: SSRO; HELIX NEBULA: NASA/NOAO/ESA; FULL MOON, MARE CRISIUM, PLEIADES, TRIFID NEBULA, ETA CARINAE, ANDROMEDA GALAXY: NOAO/AURA/NSF; ORION NEBULA, TADPOLE AND WHIRLPOOL GALAXIES: NASA/ESA; HORSEHEAD NEBULA: ESO; M57: NASA/AURA/STScI; COPERNICUS CRATER, SATURN, MARS: NASA; VENUS, JUPITER: NASA/JPL

Magnified 10x

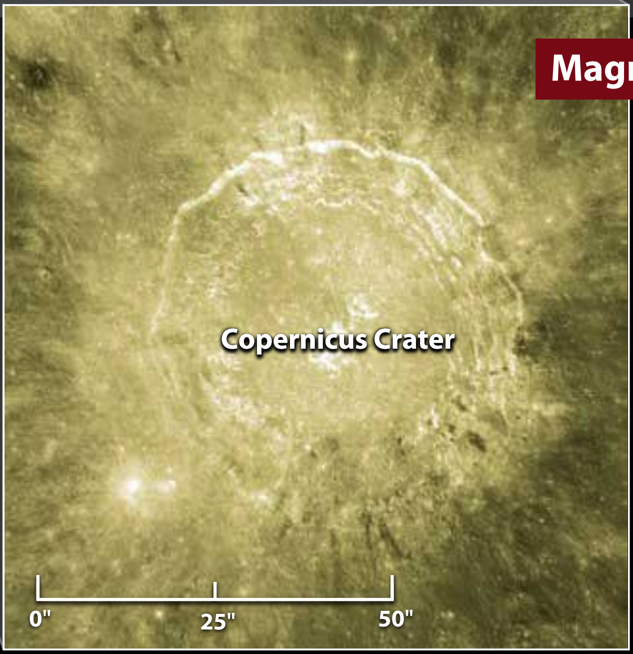

Mare Crisium
(Sea of Crises)
0'
1'
2'
3'

ZOOM IN 10 times to Mare Crisium, which could cradle the entire Hubble Ultra Deep Field.

On the other hand, the Ring Nebula (M57) or the Tadpole Galaxy (UGC 10214) could fit within the span of the Moon's 260-mile-wide (418 kilometers) Mare Crisium. This feature also spans about the same angle as the Hubble Space Telescope's Ultra Deep Field, a patch of space that takes astronomers to within a billion years of the Big Bang.

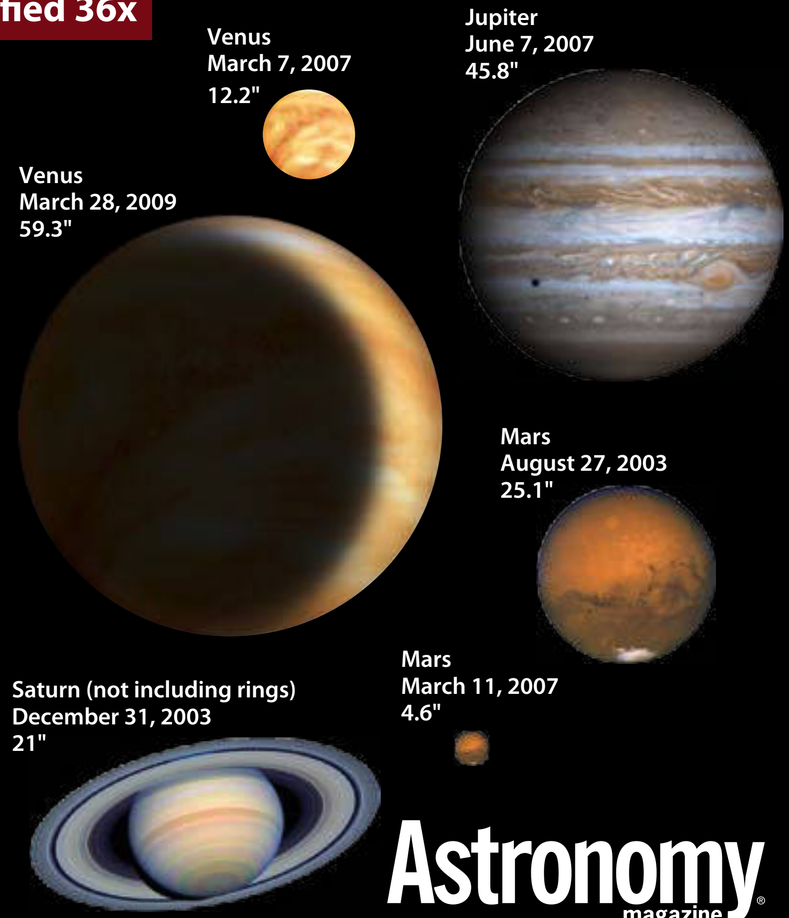

NGC 5195
The Whirlpool Galaxy
(M51)
The Tadpole
Galaxy
(UGC 10214)
Ring Nebula (M57)
Horsehead Nebula
(Barnard 33)

Magnified 36x


Copernicus Crater
0"
25"
50"

THE MOON'S Copernicus Crater is big enough to contain the apparent sizes of all planets except Venus.

Jupiter, the solar system's largest planet, could fit inside the 58-mile-wide (93 km) lunar crater Copernicus. But Venus bests them both. Near inferior conjunction, when the planet is about to slip between Earth and the Sun, Venus shows a slender crescent larger than any other planet's apparent disk.


Venus
March 7, 2007
12.2"
Jupiter
June 7, 2007
45.8"
Venus
March 28, 2009
59.3"
Mars
August 27, 2003
25.1"
Saturn (not including rings)
December 31, 2003
21"
Mars
March 11, 2007
4.6"

BY MARTIN RATCLIFFE AND ALISTER LING

JANUARY 07

Return of the evening star

There's nothing quite like Venus blazing beautifully in a colorful twilight sky. While newcomers feel a sense of wonder, old-timers relax, realizing Venus' appearance signals the start of a great stargazing session. ☾ As January begins, Venus appears slowly through the bright yellow-orange glow, low in the southwest about 30 minutes after sunset. Week by week, the cloud-covered planet inches higher and sets a little bit later. Through a telescope, Venus displays a tiny, shimmering disk. But in a few months, it will grow and thin into a resplendent crescent.

Mark your calendar for January 20, when Venus has a pretty conjunction with the crescent Moon. Find a location with an unobstructed southwestern horizon so you can watch the pair as long as possible. As the sky darkens, you should see gray earthshine — the "old Moon in the new Moon's arms" — filling out the crescent.

Speedy Mercury begins a fine evening apparition during the last week of January. It's bright — shining at magnitude –1.0 — and easy to see through binoculars to Venus' lower right. In early February, the innermost planet will be a snap to see with the unaided eye.

With all the bright, sparkling winter stars commanding the eastern sky after darkness falls, you can be forgiven if you miss Saturn closer to the horizon. Because Saturn's not a point source like a star, its light does not twinkle as it passes through the turbulent lower layers of our atmosphere. However, this turbulence blurs the planet's globe, delicate rings, and tiny moons when viewed through a telescope. Be patient, and wait until the ringed wonder climbs reasonably high in the south by 11 P.M. or so. Over the next several weeks, Saturn pulls slowly away from blue-white Regulus, Leo the Lion's brightest star.

MERCURY AND VENUS JOINED FORCES

December 30, 2004. They appear just above the horizon and right of the cactus. This month, the two come together at dusk. JOE ORMAN

Most backyard observers enjoy dynamic solar system events in part because the background universe usually doesn't change at all. Conjunctions between planets typically progress at a modest rate and can withstand a cloudy night or two. Events involving the Moon transpire much faster, however, and require clear weather on specific nights. During an occultation, the Moon blots out a background star or planet. If you're in the right place, the object can both disappear behind the Moon and reappear up to an hour or so later.

From its northernmost point next to Beta (β) Tauri January 1, the Moon slides south and east. On the morning of the 6th, Alaskans can see it occult Saturn. By the time the Sun sets that evening, the Moon lies between Saturn and Regulus. A lovely photo-op happens before dawn January 15 when Jupiter, ruddy Antares, and the waning crescent Moon all line up.

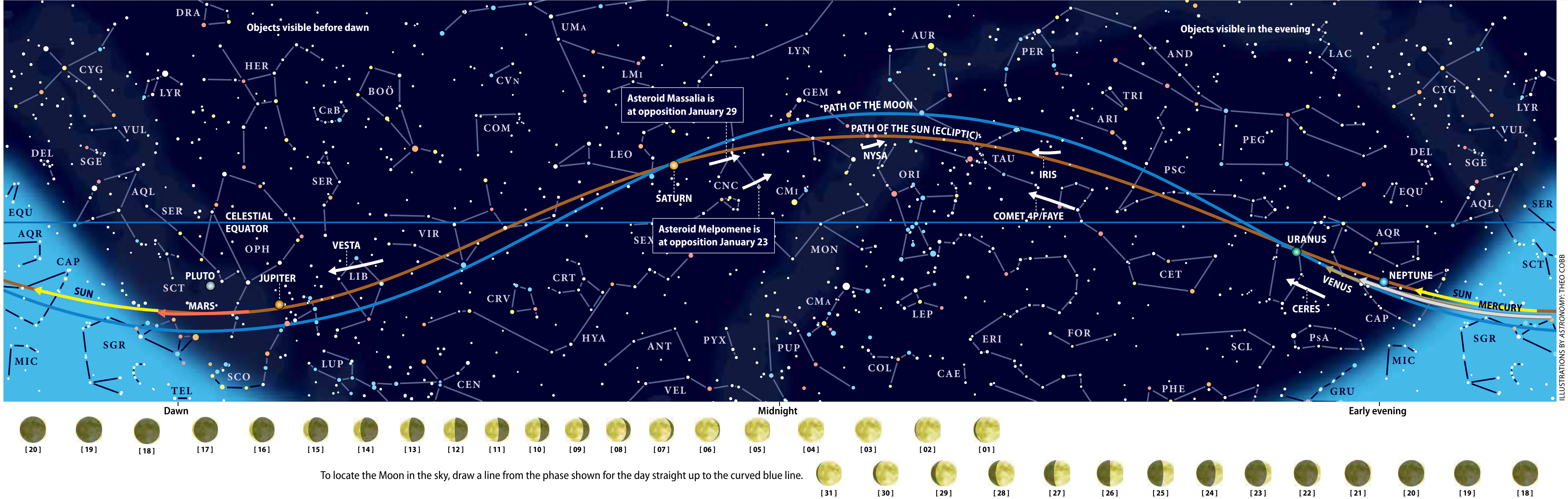
Does the sight of a slender crescent Moon only 24 hours old make you gasp? Then the even tinier sliver presented by an 18-hour newborn may take your breath away. The evening of January 19 provides a prime chance for observers along the East Coast — if you find high ground with an unobstructed southwestern horizon.

To spot the Moon, you'll need to search for it with binoculars just 20 or 25 minutes after sunset. First, locate Mercury in the bright twilight glow barely above the horizon. To the left in the same field of view lies the Moon's faint, yellow arc. By the time Earth has turned to favor West Coast observers, the Moon will be 21 hours old and positioned to Mercury's upper left. Seeing a Moon this young is far from easy — even many experienced observers have never seen one.

Planets this month

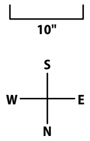
This map unfolds the entire night sky from sunset (at right) until sunrise (at left). Arrows and colored dots show motions and locations of solar system objects during the month.

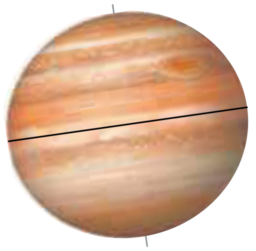
Astronomy magazine

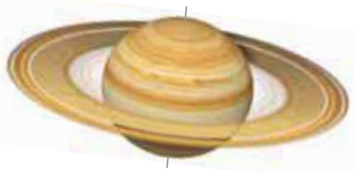

Objects visible before dawn
Objects visible in the evening
DRA
CYG
LYR
HER
CRB
BOÖ
CVN
UMA
LMI
LYN
AUR
PER
AND
LAC
CYG
LYR
VUL
DEL
SGE
AQL
SER
EQU
AQR
CAP
SCT
SGR
MIC
TEL
SCO
LUP
CEN
OPH
CELESTIAL EQUATOR
PLUTO
MARS
JUPITER
SUN
VESTA
LIB
VIR
COM
LEO
SEX
CRT
CRV
HYA
ANT
PYX
VEL
SATURN
Asteroid Massalia is at opposition January 29
Asteroid Melpomene is at opposition January 23
CNC
CMI
GEM
PATH OF THE MOON
PATH OF THE SUN (ECLIPTIC)
NYSA
ORI
TAU
IRIS
COMET 4P/FAYE
MON
CMA
PUP
COL
LEP
CAE
ERI
FOR
TRI
ARI
PSC
CET
PEG
VUL
DEL
SGE
AQL
EQU
SER
AQR
SCT
URANUS
NEPTUNE
VENUS
CERES
SUN
MERCURY
CAP
PSA
SCL
PHE
GRU
MIC
SGR
Dawn
Midnight
Early evening
[20]
[19]
[18]
[17]
[16]
[15]
[14]
[13]
[12]
[11]
[10]
[09]
[08]
[07]
[06]
[05]
[04]
[03]
[02]
[01]
[31]
[30]
[29]
[28]
[27]
[26]
[25]
[24]
[23]
[22]
[21]
[20]
[19]
[18]

ILLUSTRATIONS BY ASTRONOMY: THEO COBB

To locate the Moon in the sky, draw a line from the phase shown for the day straight up to the curved blue line.



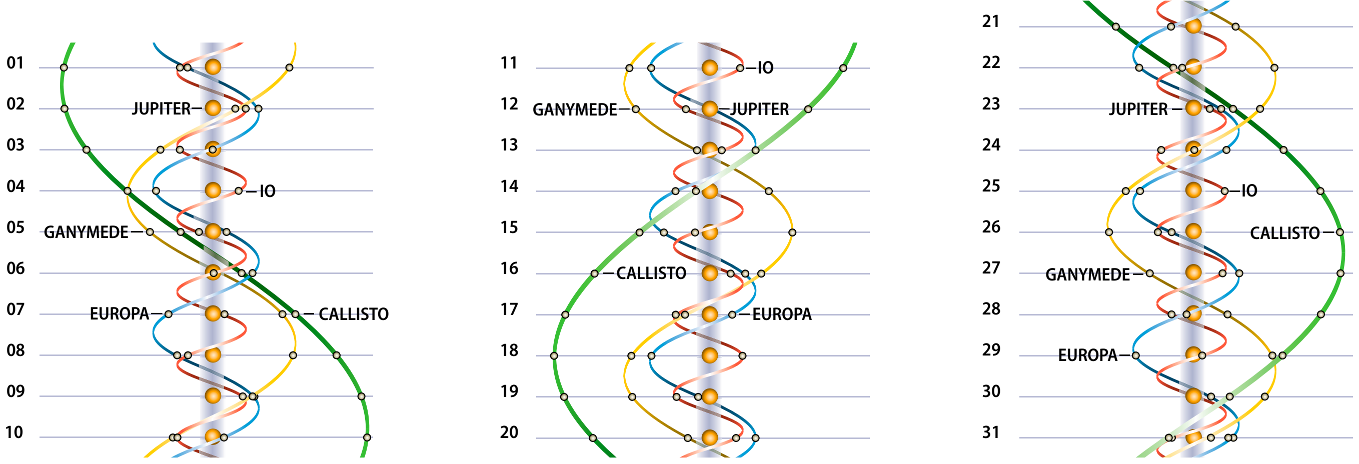




PLANETS	MERCURY	VENUS	MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
Date	January 31	January 15	January 15	January 15	January 15	January 15	January 15	January 15
Magnitude	–1.0	–3.9	1.4	–1.8	0.1	5.9	8.0	14.0
Angular size	5.8"	10.6"	4.0"	32.7"	20.0"	3.4"	2.2"	0.1"
Illumination	80%	95%	98%	100%	100%	100%	100%	100%
Distance (AU) from Earth	1.153	1.581	2.319	6.033	8.310	20.737	30.945	32.094
Distance (AU) from Sun	0.335	0.728	1.496	5.362	9.181	20.088	30.050	31.227
Right ascension (2000.0)	21h55.3m	21h05.7m	17h53.6m	16h37.6m	9h45.3m	22h54.7m	21h24.0m	17h49.3m
Declination (2000.0)	–13°43'	–18°16'	–23°53'	–21°23'	14°50'	–7°46'	–15°30'	–16°33'

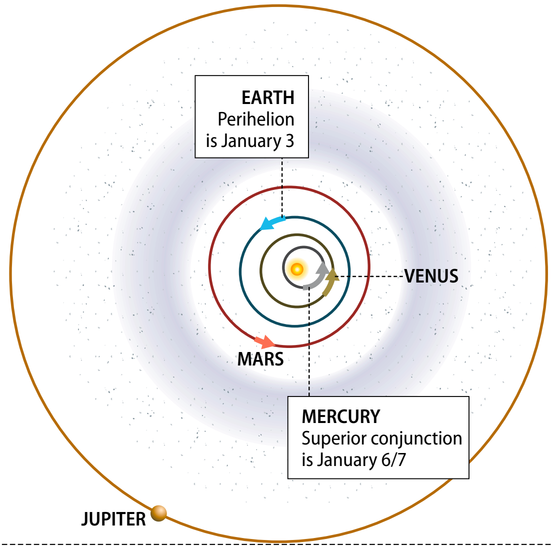
Jupiter's moons

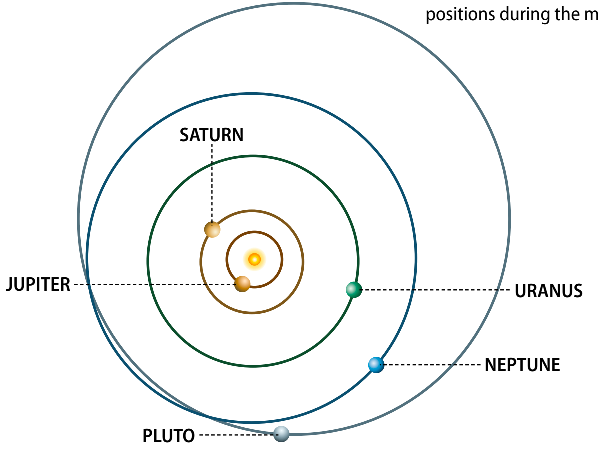
Dots display positions of Galilean satellites at 7 A.M. EST on date shown. South is at top to match the view through a telescope.



The planets in their orbits

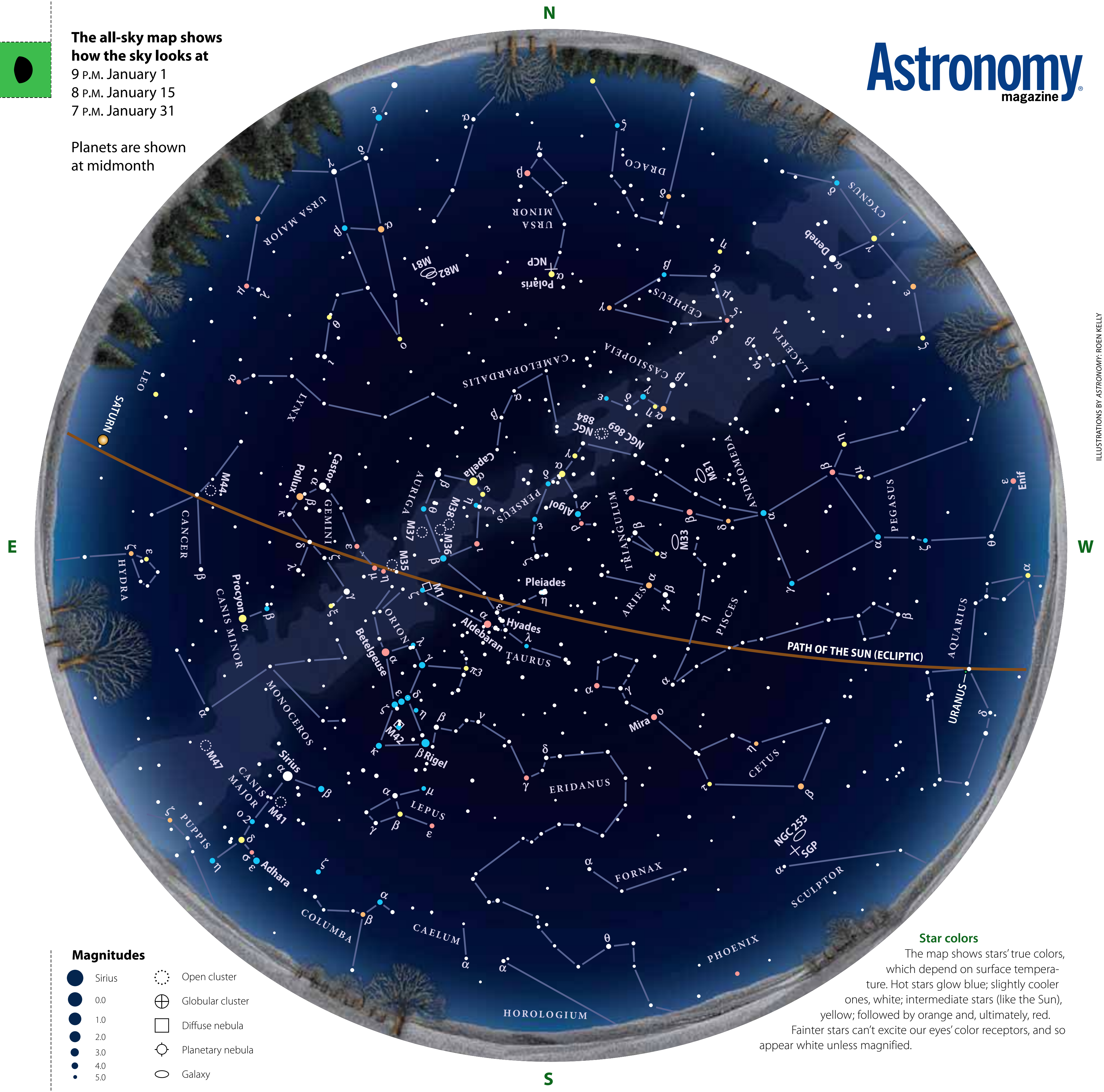
Arrows and dots show planets' positions during the month.


EARTH
Perihelion
is January 3
VENUS
MARS
MERCURY
Superior conjunction
is January 6/7
JUPITER


SATURN
JUPITER
URANUS
NEPTUNE
PLUTO

The all-sky map shows how the sky looks at
9 P.M. January 1
8 P.M. January 15
7 P.M. January 31

Planets are shown at midmonth


N
E
W
S
URSA MAJOR
URSA MINOR
DRACO
CYGNUS
Deneb
M81
M82
NCP
Polaris
CEPHEUS
LACERTA
CASSIOPEIA
CAMELOPARDALIS
LEO
SATURN
LYNX
NGC 869
NGC 884
Capella
Castor
Pollux
AURIGA
GEMINI
M38
M37
M36
M35
M1
PERSEUS
Algol
TRIANGULUM
M33
M31
ANDROMEDA
PEGASUS
Enif
M44
CANCER
HYDRA
Procyon
CANIS MINOR
Betelgeuse
ORION
Pleiades
Hyades
Aldebaran
TAURUS
ARIES
PISCES
PATH OF THE SUN (ECLIPTIC)
AQUARIUS
URANUS
MONOCEROS
M42
Rigel
Mira
CETUS
ERIDANUS
Sirius
M47
M41
CANIS MAJOR
PUPPIS
Adhara
LEPUS
NGC 253
SGP
SCULPTOR
FORNAX
COLUMBA
CAELUM
PHOENIX
HOROLOGIUM

Magnitudes

● Sirius
● 0.0
● 1.0
● 2.0
● 3.0
● 4.0
● 5.0

◌ Open cluster
⊕ Globular cluster
☐ Diffuse nebula
⌖ Planetary nebula
⬭ Galaxy

Star colors

The map shows stars' true colors, which depend on surface temperature. Hot stars glow blue; slightly cooler ones, white; intermediate stars (like the Sun), yellow; followed by orange and, ultimately, red. Fainter stars can't excite our eyes' color receptors, and so appear white unless magnified.

How to use this map

This map portrays the sky as seen near 35° north latitude at times shown in the upper left corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

Astronomy magazine

january 07

SUN.	MON.	TUES.	WED.	THURS.	FRI.	SAT.
	[01]	[02]	[03]	[04]	[05]	[06]
[07]	[08]	[09]	[10]	[11]	[12]	[13]
[14]	[15]	[16]	[17]	[18]	[19]	[20]
[21]	[22]	[23]	[24]	[25]	[26]	[27]
[28]	[29]	[30]	[31]			

ILLUSTRATIONS BY ASTRONOMY: ROEN KELLY

03 Full Moon occurs at 8:57 A.M. EST

Earth is at perihelion (91.4 million miles from the Sun), 3 P.M. EST

Quadrantid meteor shower peaks

04 Jupiter passes 5° north of Antares, 11 P.M. EST

06 The Moon passes 0.9° north of Saturn, 1 P.M. EST

The Moon passes 1.2° north of Regulus, midnight EST

07 Mercury is in superior conjunction, 1 A.M. EST

10 The Moon is at apogee (251,242 miles from Earth), 11:25 A.M. EST

11 Last Quarter Moon occurs at 7:45 A.M. EST

The Moon passes 1.1° south of Spica, 3 P.M. EST

15 The Moon passes 0.5° south of Antares, 8 A.M. EST

The Moon passes 6° south of Jupiter, noon EST

16 The Moon passes 5° south of Mars, 9 P.M. EST

18 Venus passes 1.4° south of Neptune, 1 P.M. EST

New Moon occurs at 11:01 P.M. EST

20 The Moon passes 2° south of Neptune, 8 A.M. EST

The Moon passes 0.8° south of Venus, noon EST

22 The Moon passes 0.4° north of Uranus, 1 A.M. EST

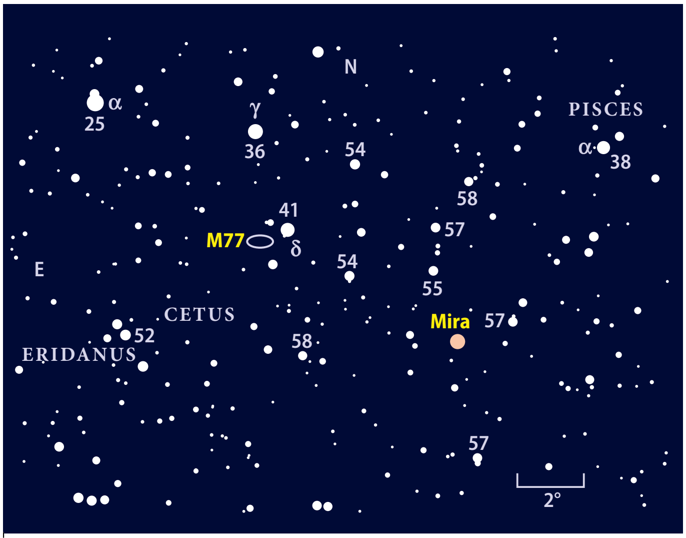
The Moon is at perigee (227,997 miles from Earth), 7:31 A.M. EST

25 First Quarter Moon occurs at 6:01 P.M. EST

ONLINE EXTRA For definitions of terms, visit www.astronomy.com/glossary.

THE DEEP SKY

Mira the wonderful



ASTRONOMY: ROEN KELLY

CETUS OFFERS A WONDERFUL STAR, Mira, and the prototype Seyfert galaxy, M77, to backyard observers. Cetus rides high in the south after sunset during January.

A special ruby stars in this story of the sea. Mimicking the graceful arc of a humpback whale surfacing and submerging, the celestial whale Cetus rises in the east, crests in the south halfway to the zenith, and sets in the west. During January, Cetus appears at its highest just after darkness falls. Seen from the Southern Hemisphere, Cetus performs a full breach nearly overhead.

Once every 11 months, a faint, pale-red star brightens to a lovely orange-topaz and adorns the blank central area of the Whale. The star, known as Mira, then returns slowly to obscurity over the next several months.

Until David Fabricius (1564–1617) discovered Mira's variability in 1596, Cetus must have swum in poorly charted waters. Even the esteemed celestial cartographer Johannes Bayer (1572–1625) thought Mira was just an ordinary star. Bayer assigned each bright star a Greek letter, a system we still use today, and designated Mira Omicron (ο) Ceti.

Unlike the clockwork plunge and recovery of Algol in Perseus, Mira flaunts its variability. In 1779, Sir William Herschel (1738–1822) witnessed a peak that challenged the brightness of 1st-magnitude Aldebaran. In other years, Mira barely surfaced to the unaided eye. How will it compare this time to its typical peak near magnitude 3.5? No one knows. Mira's pulsation period averages 332 days, but it can be fast or slow by as much as 20 days. This year, astronomers predict maximum to come in early March.

Use the chart above to gauge Mira's brightness. The numbers next to some stars are their magnitudes, with the decimal points removed to avoid confusing them with stars. To estimate Mira's magnitude, find one star a little brighter than Mira and a second a bit fainter. Then, figure where Mira falls between those two.

SEYFERT GALAXY M77'S CORE BLAZES brighter than a typical galaxy's because gas there fuels a supermassive black hole. FRANCOIS AND SHELLEY PELLETIER AND ADAM BLOCK/NOAO/AURA/NSF

Heart of darkness

Things are not always what they seem. Edwin Hubble (1889–1953) showed that many of the sky's nebulous patches of light are distant galaxies. Albert Einstein (1879–1955) taught us that extremely dense objects warp space and behave in counterintuitive ways.

The blazing, pinpoint core of spiral galaxy M77 led astronomer Carl Seyfert to recognize it as a new class of galaxies with active nuclei. Later, astronomers realized M77 lies on the quieter side of the activity range, a scale that places quasars at the top. Galaxies like M77 are now known as Seyferts.

You shouldn't have too much trouble finding M77. First, locate the three brightest stars in Cetus' head: Alpha (α), Gamma (γ), and Delta (δ) Ceti. From Delta, slide 50' (a bit less than 2 Moon-widths) southeast. You'll notice M77's bright core right away. Hidden inside this fuzzy dot is a black hole devouring ripped-apart stars.

Under a dark sky, the galaxy's disk becomes visible. Although most backyard observers will need at least a 12-inch scope to see spiral structure, a patient observer should notice some mottling through a 5-inch. Afterward, aim your scope at M32, one of the Andromeda Galaxy's companions, and you'll see a much smoother distribution compared with M77's lumpiness.

Martin Ratcliffe *is the former president of the International Planetarium Society.* **Alister Ling** *is a meteorologist for Environment Canada.*

THE PLANETS

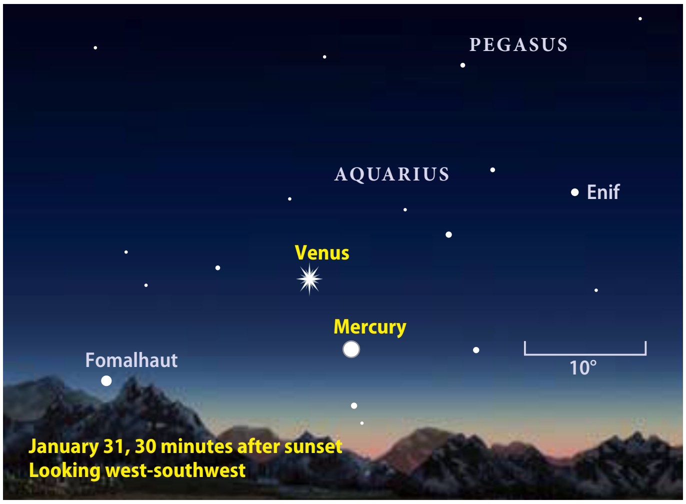
Venus rules the early evening

Planetary observers have tempting targets throughout these long winter nights. Venus lies low in the southwest during evening twilight and grows more prominent as January progresses. Mercury joins Venus late in the month. Saturn rises a couple of hours after sunset and appears spectacular among the stars of Leo. Then, as dawn approaches, Jupiter and Mars both come into view.

Brilliant **Venus** pierces the colorful twilight glow all month. On New Year's Day, the "evening star" shines at magnitude –3.9 and stands 6° above the southwestern horizon 30 minutes after sunset. Its visibility improves with each passing week. By month's end, Venus lies 10° high nearly an hour after sunset.

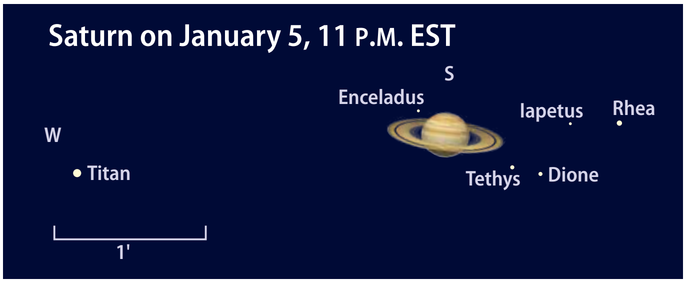
Aim your telescope at Venus in early January, and you'll see a nearly full disk that spans 10". The planet's 96-percent-lit phase wanes imperceptibly, to 92-percent lit, during the month. More dramatic changes await observers this spring and summer. On January 20, look for a slim crescent Moon just 3° above Venus.

By the end of the month, Venus has company. Climbing out of the twilight, **Mercury** begins a fine evening show. You can spot this normally elusive planet 10° below Venus January 22. It shines then at magnitude –1.1 — far fainter than Venus — and, like its brighter cousin, it shows a nearly full disk when seen through a telescope. However, Mercury is much smaller than Venus, so its disk reaches a mere 5" across.



VENUS DOMINATES THE WESTERN SKY

after sunset throughout January. Late in the month, however, fainter Mercury comes into view below it. *ASTRONOMY*: ROEN KELLY



SATURN AND ITS RETINUE OF MOONS

put on a nice show this month. You can find the normally elusive Iapetus among a trio of similarly bright moons January 5.

Mercury changes position more rapidly than Venus. By the 31st, the two planets have closed to within 7°, while Mercury's phase has dwindled to 80-percent lit. With its increasing angular distance from the Sun, Mercury remains above the horizon a little longer and becomes easier to spot. Its visibility continues to improve through February's first week, as the planet approaches greatest elongation from the Sun.

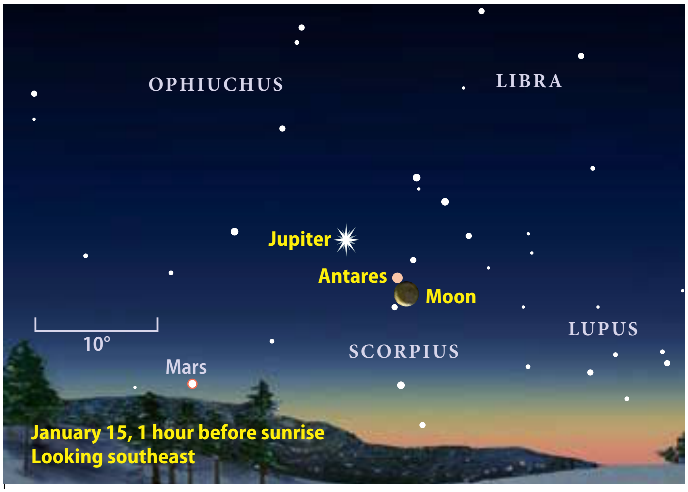
Uranus lingers in the evening sky during January, but try to catch it early in the month. It lies within 1° of 4th-magnitude Lambda (λ) Aquarii. The 6th-magnitude planet will be easy to see through binoculars.

By late January, Uranus has dipped to within 8° of Venus, and you'll have to hunt for it an hour after sunset. Wait any longer, and Uranus will be lost in the haze. **Neptune** also lies in this vicinity — passing 1.4° from Venus January 18 — but the 8th-magnitude planet glows too dimly to pierce the twilight.

Not long after Venus sets, **Saturn** appears on the eastern horizon. With opposition coming in February, the ringed planet remains in view now from evening until dawn. In the early evening, Saturn lies well below Castor and Pollux, the two luminaries of Gemini the Twins. As Saturn climbs higher, you'll see Leo the Lion's brightest star, Regulus, some 6° below it. Wait until all of Leo clears the horizon before turning your telescope on Saturn. Before then, turbulence in Earth's atmosphere will blur the planet.

Saturn shines at magnitude 0.1, outshining all the bright stars nearby: Castor, Pollux, Regulus, and Procyon. The planet lies 770 million miles from Earth in mid-January, which means the light we see takes more than an hour to reach us. The Saturn-orbiting Cassini spacecraft sends its signals by radio waves, so it also takes more than an hour to communicate with Earth.

After viewing the bland disks of Mercury and Venus, Saturn provides a dramatic punch. In mid-January, Saturn's globe measures 20" across, double Venus' apparent diameter.



ASTRONOMY: ROEN KELLY

A WANING CRESCENT MOON SLIDES just below the ruddy supergiant star Antares before dawn January 15. As a bonus, brilliant Jupiter stands watch over the two.

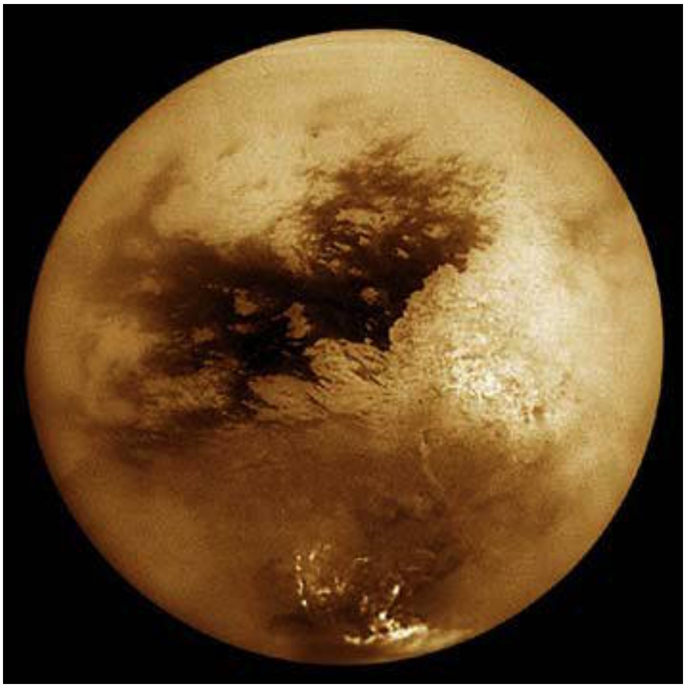
With the rings' north-south extent now down to 10", a significant part of the planet's north polar region is in view.

The rings still span 45" east to west, offering spectacular views as the rings continue to narrow. By 2009, they will appear edge-on to our line of sight, essentially disappearing for a brief period.

Saturn's moons change position noticeably from night to night, and, for some of the inner moons, from hour to hour. Titan glows at magnitude 8.4 and is the easiest one to identify. You shouldn't have any trouble singling it out unless a similarly bright star lies in the same field of view, as happens January 18. Titan passes due north of Saturn January 3 and 19, and due south of the planet January 11 and 27.

Outer moon Iapetus passes north of Saturn between January 5 and 7. While all the other visible moons change position quite rapidly, Iapetus in its 80-day orbit takes its sweet time, so you won't see much change from night to night. This two-faced moon brightens as it heads toward greatest western elongation January 25. It then glows at magnitude 10.1, some 5 times brighter than when it was well east of the planet in late December.

With Saturn nearing opposition, it's a great time to look for its inner moons. Each now has its own personality, revealed through the thousands of images returned by Cassini. Enceladus, where liquid water lurks just beneath the frozen surface, glows at magnitude 11.8 and lies a little beyond the outer edge of the rings. Tethys shows up more easily because it's both brighter (magnitude 10.3) and orbits farther from Saturn. It completes one revolution every 1.9 days. Dione scoots around Saturn every 2.7 days. At magnitude 10.4, it's as easy to spot as Tethys. Rhea, the brightest of these inner moons (magnitude 9.7), takes 4.5 days to complete a circuit.



LAKES AND SEAS OF LIQUID METHANE dot the surface of Saturn's moon Titan. Through backyard scopes, however, all you'll see is an 8th-magnitude dot of light. NASA/JPL/SSI

Saturn remains the most inviting planetary target until dawn, but by the wee hours, it has some competition. **Jupiter** rises in the southeast around 4 A.M. in mid-January. You'll have no problem identifying this planet, which gleams at magnitude –1.8 and easily outshines every other point of light in the morning sky.

Jupiter doesn't gain much altitude until twilight begins, so you'll want to wait until then to get a good view of it through your scope. When you do, you should spot at least two dark, parallel cloud belts running across the planet's 33"-diameter disk. You'll also see Jupiter's four bright moons: Io, Europa, Ganymede, and Callisto.

Jupiter resides in Ophiuchus some 5° north of 1st-magnitude Antares, the brightest star in neighboring Scorpius. A spectacular predawn sight awaits early risers January 15, when a waning crescent Moon lies just 1° to the lower right of Antares. Jupiter currently lies along the southern portion of its leisurely, 11.9-year orbit of the Sun. That means it never climbs high in the sky for Northern Hemisphere observers. (In contrast, those in the Southern Hemisphere are getting exceptional views.) Still, conditions will improve for everyone as Jupiter's June opposition approaches.

Mars pokes above the horizon as dawn breaks. The Red Planet traverses the Milky Way in Sagittarius during January. On the 17th and 18th, it passes between the Lagoon (M8) and Trifid (M20) nebulae, although these faint fuzzies will be hard to see in the gathering twilight. By month's end, Mars lies 3° north of 2nd-magnitude Nunki (Sigma [σ] Sagittarii). Mars won't reach opposition until December, so it will take a long time to climb away from the twilight glow. Expect better views by mid- to late summer.

METEORS AND MOONS

The Herdsman's bounty

The year's first week typically brings a meteor frenzy. Alas, 2007 won't be typical. The annual Quadrantid meteor shower peaks the night of January 3/4, the same night a Full Moon lights the sky from dusk to dawn.

The Quadrantids, which can produce up to 120 meteors per hour, will be hard-pressed to deliver more than a couple of dozen per hour this year. Your best bet will be to wait until an hour before twilight begins, then position yourself so a building blocks the bright Moon as it sinks in the west. Quadrantid meteors radiate from the constellation Boötes the Herdsman, which rides high in the east before dawn.

According to the American Meteor Society, the rest of January can deliver up to 20 meteors per hour before dawn under a dark sky. Several minor showers with radiants stretching from Cancer to Virgo conspire to produce these "shooting stars." The combined rates of these showers make up slightly for the lack of a good Quadrantid display. Yet only hot cocoa and many layers of clothes will make up for the winter cold in the hours before dawn.

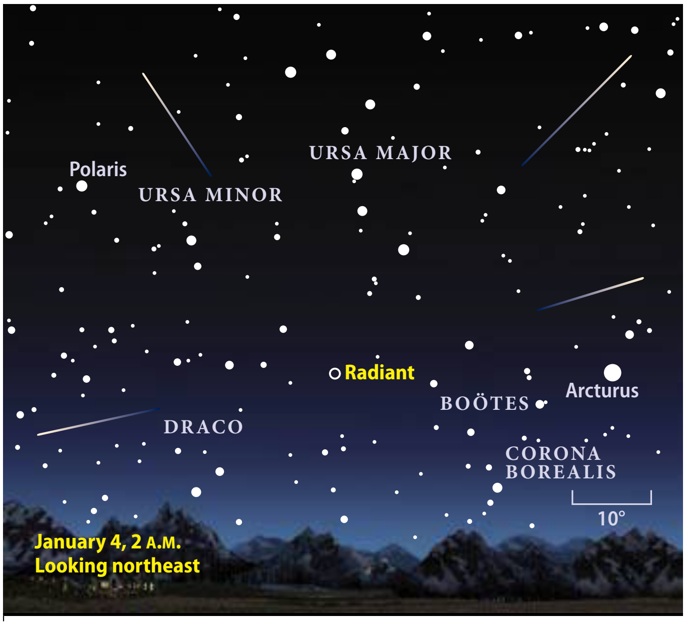
Stretched-out crater

One of the more unusual lunar craters lies near the southwestern limb. Schiller extends 111 by 44 miles, a highly elongated crater that appears even more so because it lies near the Moon's limb. At first glance, Schiller appears to be two overlapping craters, but careful tracing of its outer walls suggests it may be three or four.

Schiller's terraced inner wall shows up nicely under the low Sun angles present a few days before Full Moon and during a waning-crescent phase. (This month, the best days cluster around January 1, 14, and 30.) A small telescope is all you need to see Schiller's lava-flooded floor.

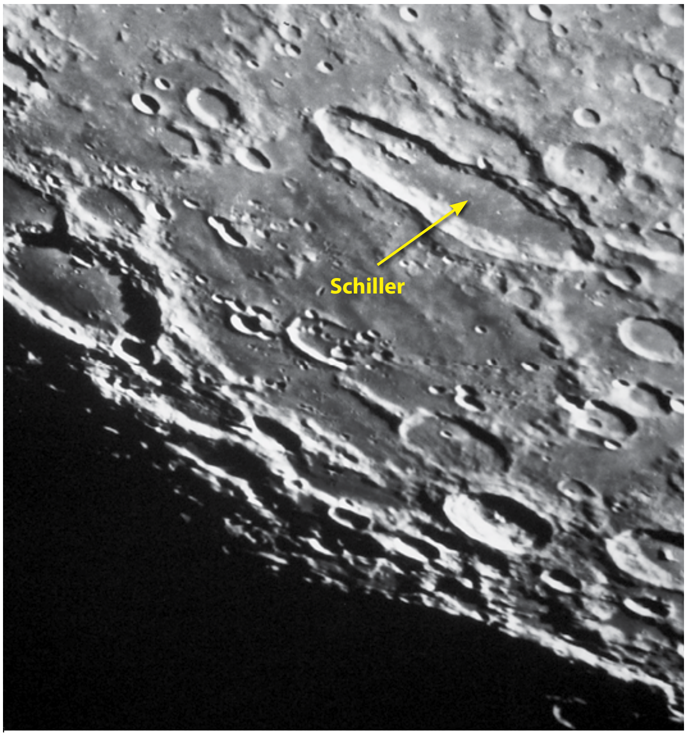
At the crater's southeastern end, a small valley connects Schiller to a tiny crater. At the northwestern end, a large ridge bisects the floor. To Schiller's south lies the Schiller-Zucchius basin, a double-ringed, pock-marked feature. The outer ring appears to form part of the walls of Rost, a decent-sized crater southeast of Schiller. Follow this ring to the south and west, and you'll find the 40-mile-wide crater Zucchius.

Charles Wood, in his book *The Modern Moon*, speculates Schiller is the impact scar left by a small, former satellite of the Moon. This idea comes from studies of similar features on Mars that planetary scientists suspect were formed by a Phobos-sized body that crashed into the martian surface.



ASTRONOMY: ROEN KELLY

THE QUADRANTID METEOR SHOWER will disappoint this year because it peaks the night of Full Moon. Still, attentive observers may see 20 or so meteors per hour.



FROM CONSOLIDATED LUNAR ATLAS (LPL/UA)

ELONGATED LUNAR CRATER SCHILLER sits in the highland region near the Moon's southwestern limb. Studies show Schiller to be at least two overlapping craters.

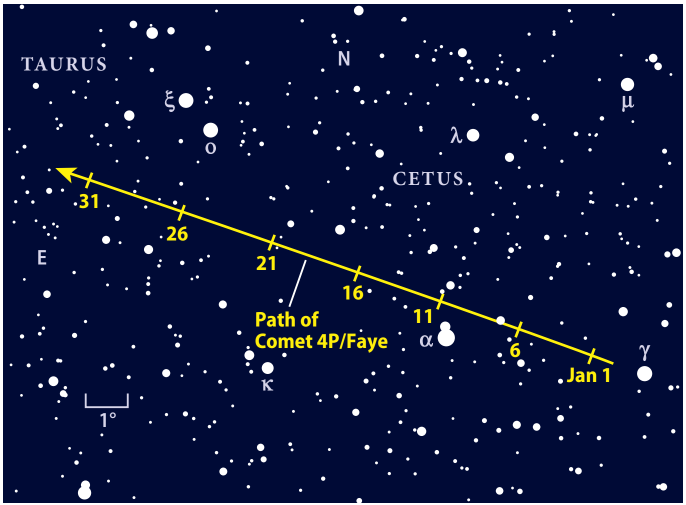
COMETS AND ASTEROIDS

Red Planet neighbor

Astronomers have telescopes trained on the sky to search for asteroids and comets that potentially threaten Earth. In the future, once humans settle on the Red Planet, scientists will also have to be on the lookout for Red Planet impactors. Because Mars lies on the inner edge of the asteroid belt, the potential danger is considerably higher there than on our "pale blue dot."

It's not just asteroids, either. Comets also swing past Mars, and 4P/Faye is a prime example. This dirty snowball has its aphelion, or farthest point from the Sun, not far from Jupiter's orbit. The strong gravitational influence of the king of planets perturbs orbits both subtly and wildly. It's only a matter of time before Jupiter changes Faye's orbit. The comet's perihelion, its closest point to the Sun, currently lies just outside Mars' orbit. One day, it might be modified in just the wrong way.

Comet 4P/Faye crosses the sky in a similar fashion to Mars. It remains visible for a long time because it orbits the Sun in the same direction as Earth and at only a slightly slower speed. This month, you can find Faye among the background stars of northern Cetus. The comet should glow at 10th magnitude, a fuzzball similar in brightness and appearance to many of the galaxies backyard observers come across in Virgo. Chances are Faye will be a disappointment from city backyards or when the Moon casts a lot of light, so plan to head to a dark-sky site around mid-January.

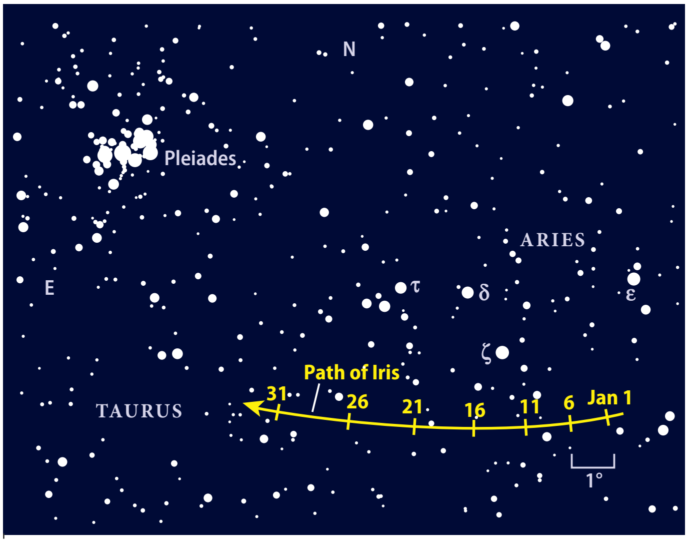


COMET 4P/FAYE MARCHES EASTWARD through northern Cetus throughout January. The 10th-magnitude comet should be visible through a 4-inch scope. *ASTRONOMY*: ROEN KELLY

Stepping on the Bull

The beautiful Pleiades star cluster serves as a conspicuous guide to finding the main-belt asteroid 7 Iris. Looking through your finder scope, slew southwest two fields (about 10°) to reach Delta (δ) Arietis, the brightest star in this region. Then use the map above to zero in on the asteroid. Iris fades from magnitude 8.2 to 9.0 this month, bright enough to see from the suburbs through a 4-inch scope.

Don't try for Iris at January's beginning — wait a few days until the bright Moon slides away from this area. On the 7th, Iris passes close to a star of similar magnitude. In such cases, it's not always easy to tell which object is the asteroid and which one is the star. Make a quick sketch of the eyepiece field to anchor a pattern. Then, return a couple of hours later to pick out the moving interloper. On January 20, a similar conjunction takes place, except the background star shines a magnitude brighter, making identification a snap.



ASTRONOMY: ROEN KELLY

IRIS LIES SOUTHWEST OF THE PLEIADES this month. Use the bright star cluster as a guide to find Iris' field, then watch for a few hours to see which "star" moves.

English astronomer John Russell Hind discovered Iris — the first of his 10 discoveries — August 13, 1847, from his private observatory in London. The first four asteroids were found soon after the turn of the 19th century. In those early days, however, it took decades to find the next handful. It all had to be done by eye at the telescope — recording objects' positions, then meticulously comparing them to star catalogs, looking for any points of light that didn't belong. Today, we have the luxury of computers doing the drudgery. A

ORION® TELESCOPES & BINOCULARS

Our 31st YEAR

Select from over 1,000 products

(800) 447-1001

OrionTelescopes.com

EVERYTHING FOR THE AMATEUR ASTRONOMER — DELIVERED DIRECT

TELESCOPES

New Crayford-style focuser! (excl. XT6)

XT12
XT10
XT8
XT6

Bonus Accessory Pack
With Any Orion SkyQuest™ Classic or IntelliScope® Dobsonian
Up to $99.90 Added Value
FREE!

SkyQuest™ XT IntelliScope® Dobsonians

Space is infinite. Your patience is not. Avoid tedious truss-tube designs and get a Dob that's faster to set up, has a solid-wall tube for superior contrast, has altitude tension adjustment for optimal balance, is amply portable, and allows *computerized pointing* to 14,000+ objects.

XT12 IntelliScope	**$1,099.95***	**XT8 IntelliScope**	**$599.95**
X10 IntelliScope	**$769.95**	**XT6 IntelliScope**	**$479.95**

* Prices *INCLUDE* optional Computerized Object Locator with 14,000-object database.

Computerized EQ Telescopes

Orion® SkyView™ Pro 8 EQ Reflector
Terrific deep-space probe with f/4.9 parabolic optics and 2" focuser.
$799.95 with IntelliScope Computerized Upgrade Kit

Orion® Sirius™ 80ED EQ-G Apo Refractor
An outstanding instrument for CCD or DSLR imaging.
$1,299.95 with Dual-Axis Controller
$1,599.95 with GoTo Controller

Orion® Atlas™ 11 EQ-G Schmidt-Cassegrain
Take your deep-sky aspirations to the limit.
$2,699.95 with Dual-Axis Controller
$2,999.95 with GoTo Controller

Great Beginner Scopes

Orion® StarBlast 4.5 EQ
Popular wide-field 4.5" reflector will delight the whole family with amazing views. Includes EQ mount, two Expanse eyepieces, EZ Finder, and more.
$199.95

Orion® StarSeeker 130 GoTo
Astronomy made easy! Automatically points to 4000+ celestial objects. Superb parabolic optics. Perfect for beginners.
$389.95

MOUNTS

New Upgraded hand controller.

Orion Atlas™ EQ-G GoTo Mount
We added brains to the Atlas mount's brawn and the result is the most affordable heavy-duty GoTo mount you can buy. Load capacity of 40 lbs., nine slew speeds, backlash compensation, PEC, and autoguider port. Database of 13,436 objects. Requires 12-volt DC power, sold separately.
$1,429.95

Atlas EQ-G with Dual-Axis Controller (non-GoTo)
$1,099.95

ACCESSORIES

Orion StarShoot™ Deep Space Color Imager
Capture amazing color shots of galaxies and nebulas with a single exposure! Thermoelectric cooling reduces noise for superior image quality. Includes MaxIm DL Essentials Edition software.
$399.95

Visit the StarShoot Image Gallery at OrionTelescopes.com!

UltraBlock Filters
Narrowband filters dramatically improve contrast on emission nebulas to reveal more detail. Also excellent for viewing in heavily light-polluted skies.

1.25"	**$79.95**
2"	**$99.95**
SCT	**$109.95**

Stratus™ Wide-Field Eyepieces
With a 68-degree apparent FOV, Stratus give you the BIG picture. Each has giant 1-1/4"-diameter eye lens and 20mm eye relief, plus fully multi-coated optics. Eight different focal lengths.
From $119.95

3-Element "Apo" 2x Barlows
These premium-quality 2x power boosters boast 3-element, fully multi-coated optics that render sharper, more color-correct images than standard achromatic Barlow lenses.

Shorty-Plus 2x, 1.25"
27mm clear aperture **$79.95**
Orion 2x, 2"
44mm clear aperture, includes 1.25" eyepiece adapter **$179.95**

FREE Color Catalog!
Call toll-free (800) 447-1001 or request it online.
When ordering, mention key code WMA
Prices subject to change

We Treat Our Customers Like Stars!

24 Hour Toll-Free Orders: (800) 447-1001
OrionTelescopes.com

MONEY-BACK 100% Satisfaction GUARANTEE

Information/Advice:
(800) 676-1343

IMAGINOVA.

Progress report on 22" Bino's. Compare with last month's ad.

Get Temperature Compensation Results without TC Costs
Using JMI Smart Focus with Software Bisque's CCDSoft (using @Focus) or Cyanogen's MaxIm DL/CCD (using SharpStar), the focus corrections are made automatically by comparing the sharpness of the stars. You get proven results for all but the longest exposures.

JMI introduces a whole new line of Crayford focusers with all the features you expect from JMI, plus a whole lot more. JMI gives you big bang for the buck. Our prices are for the complete focuser, not the starting price as others do.

JMI's NEW Event Horizon line of focusers. Dual speed with mechanical counter.

Prices start at $149

EV-1 Model

NEW MicroSlew dual motors for slewing, centering and following objects.

Vixen Porta Mount

$199.95 ($9)

Encoders and computers available, compatible with motors

The RB-16 loads easily into Mini Vans. Be ready to observe. No disassembly necessary.

Dimensions 39" high, 47" wide. Tube length is 6'.

A LEGEND RETURNS, THE NGT-18 BACK BY POPULAR DEMAND

NOW WITH GO-TO COMPUTER

$14,900
18" f4.5

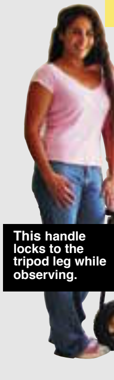
JMI
The Company To Watch

Order Now!
1-800-247-0304
Visa & Mastercard accepted.

See jmitelescopes.com

Wheely Bars starting at $179.95 ($15)

JMI's answer to roll-off observatories.
You could save enough to buy an RB-16



This handle locks to the tripod leg while observing.

"THE RIDE"
Available with or without motor.

For the 14", 16" and 20" RCX

All-terrain upgrade starting at $189.95 ($20)

JMI Cases fit most popular telescopes.

NEW! Cases in stock for RCX 10" and 12", CPC 8" and 11", LX200 7" Mak

This LX 200 14" Case will fit in the back seat of a Toyota Corolla.

Padded Handles fold away for storage

10" Pneumatic Tires recessed for low profile.

Where are you going to find stuff like this? Only at JMI!

JMI Accessories for the Lightbridge

New Shroud	$75 ($8)
New MOTOFOCUS	$139.95 ($8)
New MAX computers	$399.00 ($10)

Christmas Special
10% OFF MAX Computers
Expires Dec. 31

NEW PC Focus Control

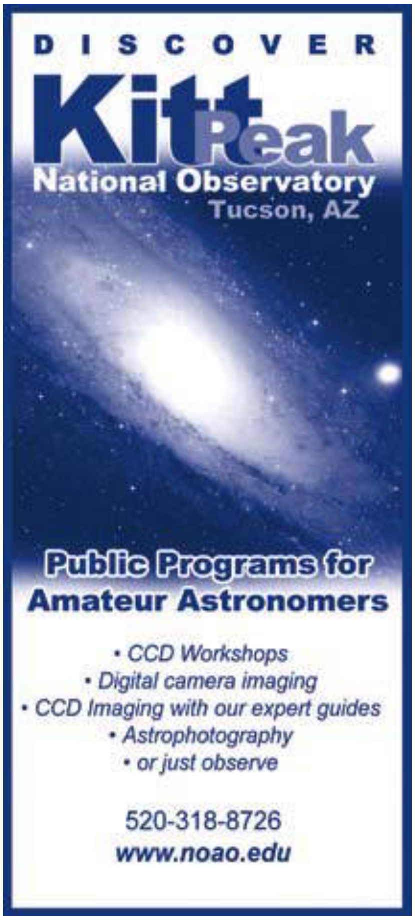
Provides basic PC computer control of any JMI MOTOFOCUS ever made. No other software or encoders required.

Christmas Special
Reg. $139
Take
$30
OFF
Expires Dec. 31

LIGHTBRIDGE

Prices are subject to change.

JMI Telescopes - Jim's Mobile, Inc. - 8550 W 14th Ave - Lakewood, CO 80215 - U.S.A.
Info 303-233-5353 - Fax 303-233-5359 - Orders 800-247-0304 - info@jmitelescopes.com



DISCOVER
Kitt Peak
National Observatory
Tucson, AZ

Public Programs for Amateur Astronomers

- *CCD Workshops*
- *Digital camera imaging*
- *CCD Imaging with our expert guides*
- *Astrophotography*
- *or just observe*

520-318-8726
www.noao.edu

ASTRONOMY CAMP
AN "IMMERSION" ADVENTURE AT A RESEARCH OBSERVATORY

The University of Arizona in Tucson — "The Astronomy Capital of the World" — is proud to continue its award-winning Astronomy Camps for students, adults, and educators.

ACTIVITIES INCLUDE:

Eyepiece viewing, solar imaging, CCD imaging & spectroscopy of celestial objects through 12", 40", 60" and 61" telescopes at Mount Lemmon Observatory near Tucson

Interactive lectures & hands-on activities led by astronomers on topics from the solar system to cosmology

Tour of Mirror Laboratory

Applications of computer and engineering technologies

CAMP DATES
GIRL SCOUT LEADERS: April & September
ADULTS (Beginning+Advanced): May 19-22
TEENS (Beginning): June 4-10
TEENS (Advanced): June 12-20
EDUCATORS: June 22-26
ADULTS (Beginning): Nov. 2-4

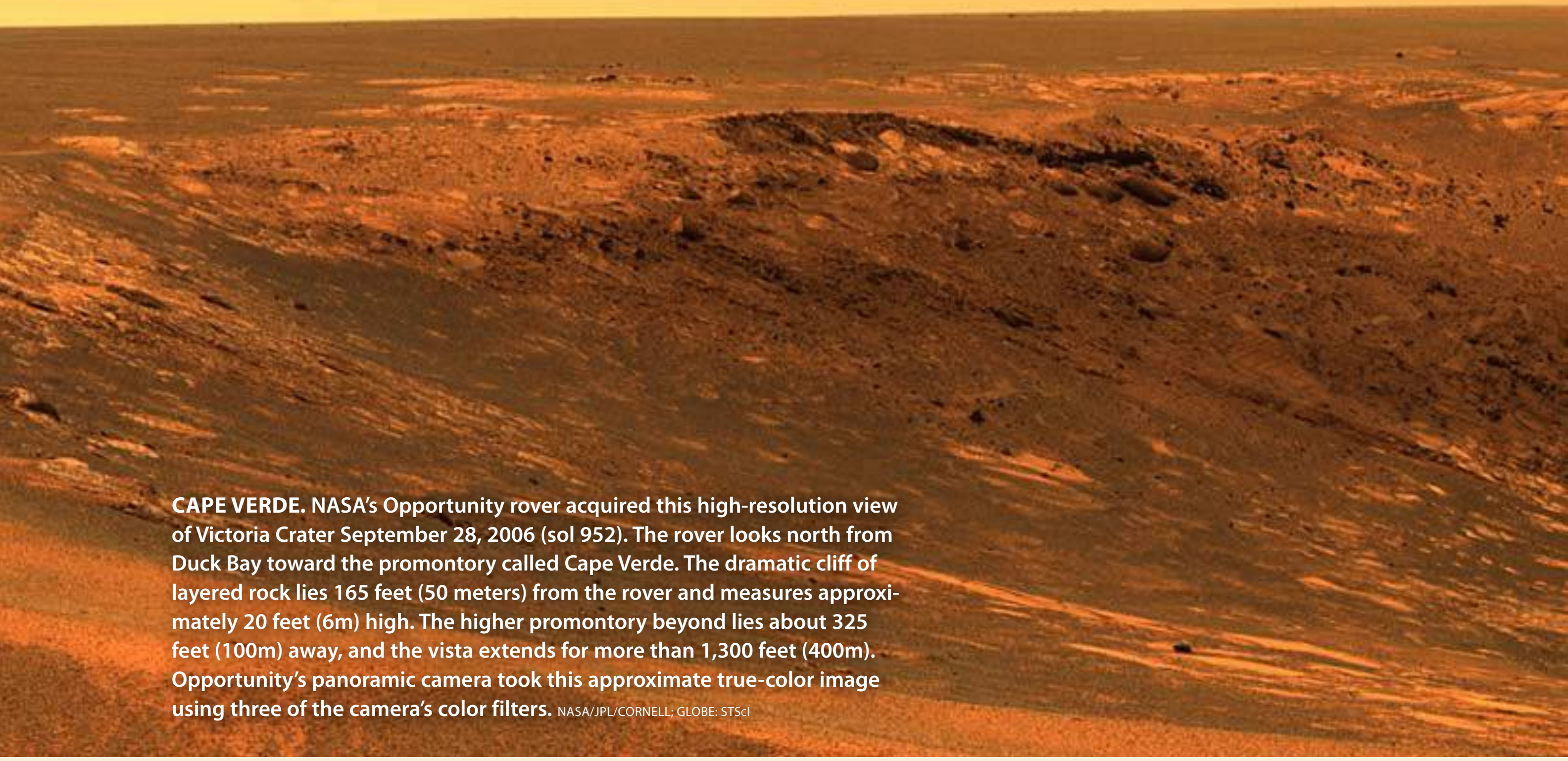
COST
Adults & Educators: $550
Teens: $700- $800 (scholarships available)

REGISTRATION
E-mail to:
dmccarthy@as.arizona.edu
http://www.astronomycamp.org

UNIVERSITY OF ARIZONA ALUMNI ASSOCIATION

ASTRONOMY CAMP

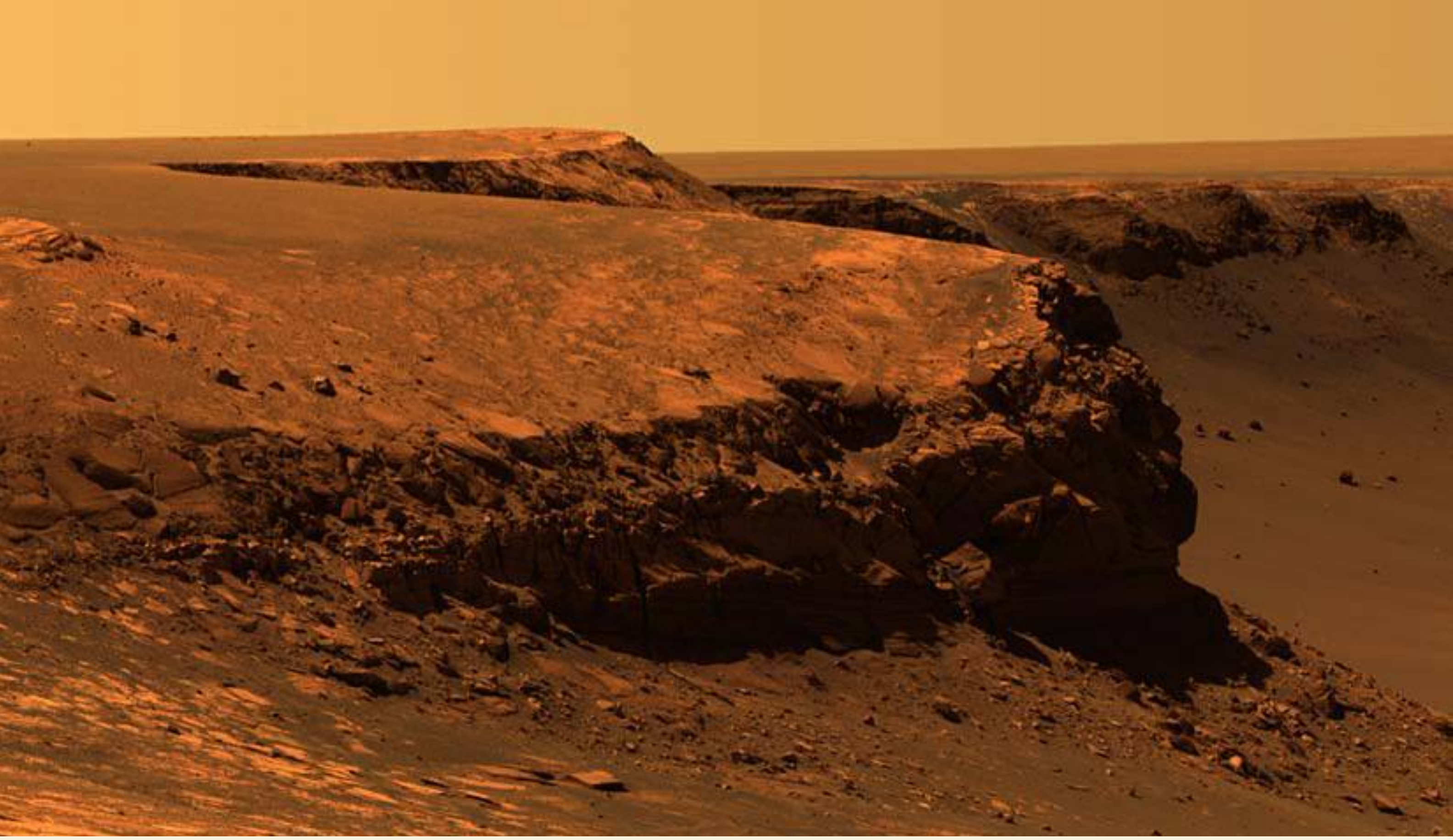
Planetary photo album

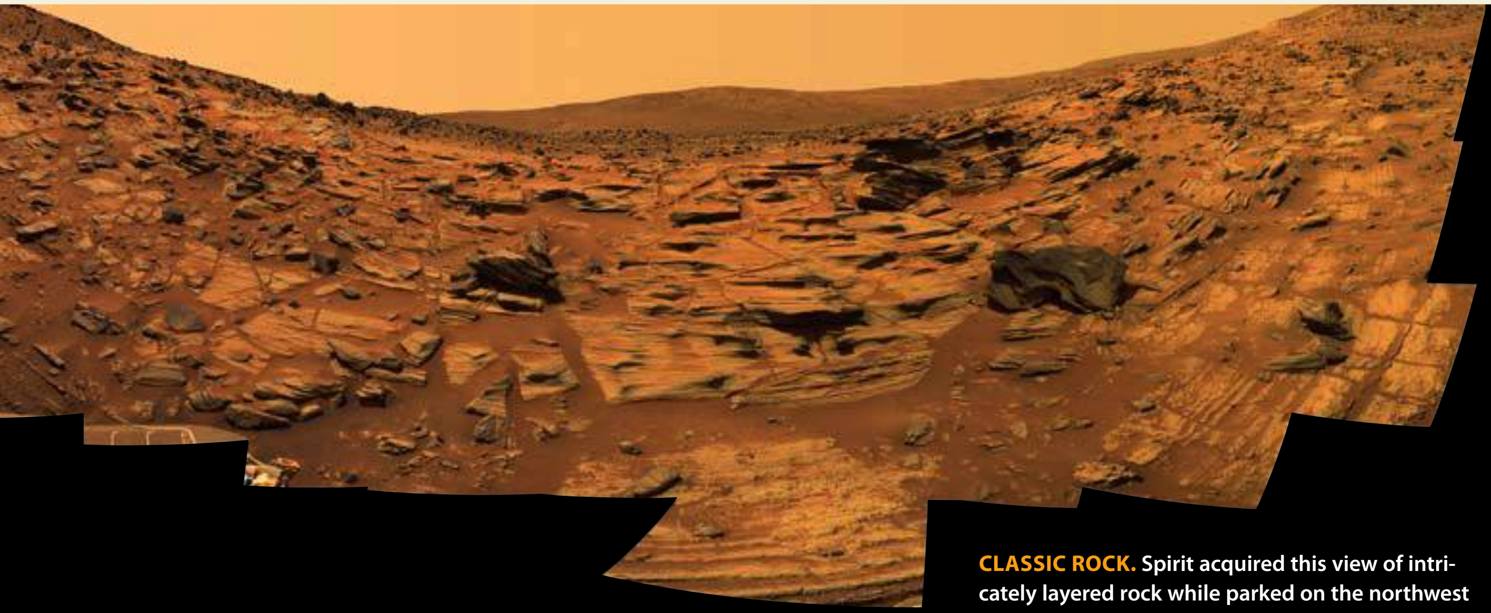


CAPE VERDE. NASA's Opportunity rover acquired this high-resolution view of Victoria Crater September 28, 2006 (sol 952). The rover looks north from Duck Bay toward the promontory called Cape Verde. The dramatic cliff of layered rock lies 165 feet (50 meters) from the rover and measures approximately 20 feet (6m) high. The higher promontory beyond lies about 325 feet (100m) away, and the vista extends for more than 1,300 feet (400m). Opportunity's panoramic camera took this approximate true-color image using three of the camera's color filters. NASA/JPL/CORNELL; GLOBE: STScI

Portraits from Mars

Images from Spirit and Opportunity turn raw science into artistic landscapes. /// **BY JIM BELL**

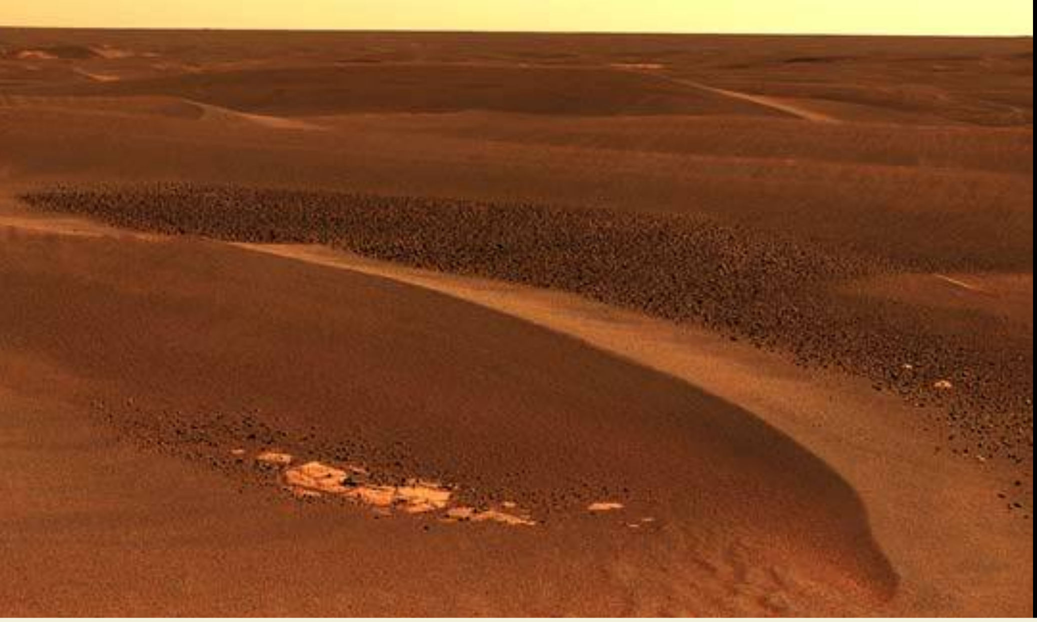




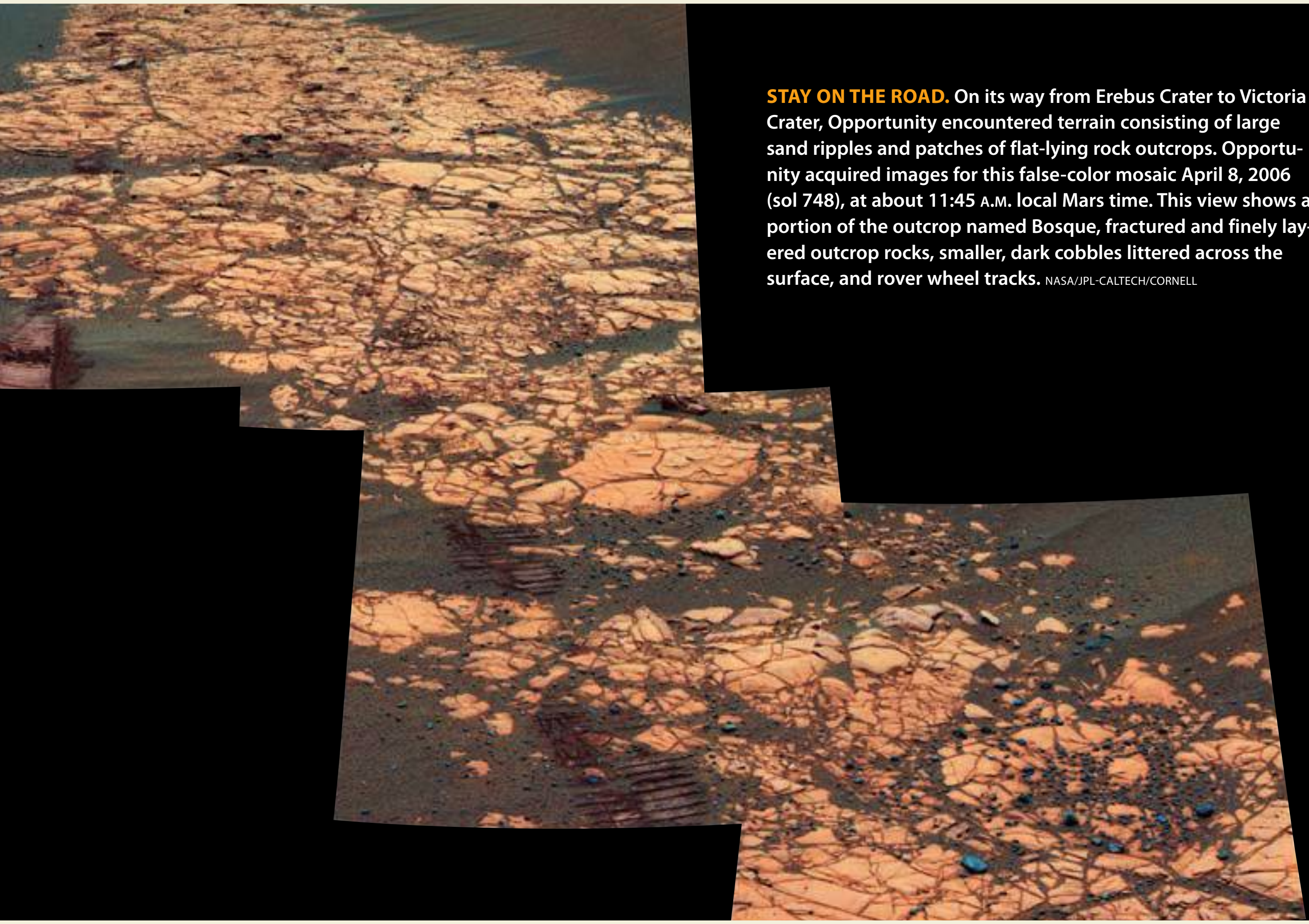
CLASSIC ROCK. Spirit acquired this view of intricately layered rock while parked on the northwest edge of the bright semicircular feature known as Home Plate. The rover perched at a 27° tilt, resulting in the mosaic's U shape. NASA/JPL-CALTECH/USGS/CORNELL

The intrepid Spirit and Opportunity rovers have survived — and thrived — on Mars for nearly 10 times their expected lifetimes. Both have returned thousands of spectacular images and other information to help astronomers literally rewrite the textbooks about martian history. Each image is, in a sense, a portrait, sent as the rovers spend a working vacation far from home.

Spirit and Opportunity were not the first missions to land, rove, or acquire images of Mars' ruddy alien landscape. Two Viking landers in 1976 and the Mars Pathfinder lander (and its Sojourner micro-rover) in 1997 came before. Those missions were also phenomenal technical and scientific successes. Each sent back tens of thousands of images that revealed the Red Planet's surface to be



COBBLED TOGETHER. As Opportunity traveled from Erebus Crater toward Victoria Crater, the rover navigated along exposures of bedrock between large wind-blown ripples. Here, scientists studied fields of cobbles, which sometimes appear on trough floors between ripples, and the banding patterns seen in large ripples. The rover's panoramic camera took this image April 27, 2006 (sol 802). This mosaic spans about 30°. The cobbles nestled among the wind-driven ripples measure about 8 inches (20 centimeters) high. NASA/JPL-CALTECH/CORNELL



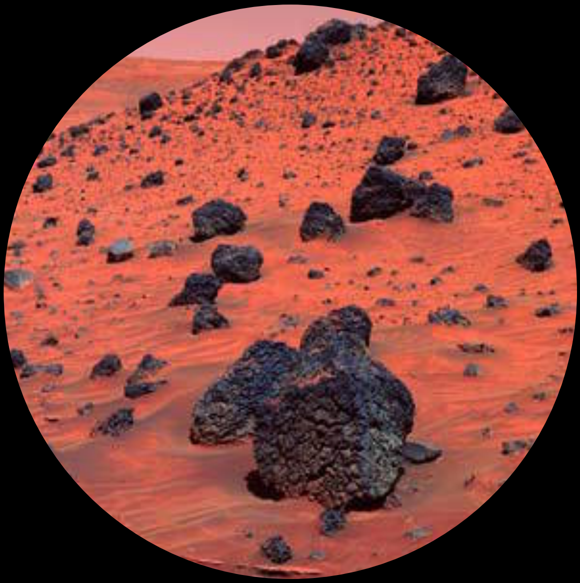
STAY ON THE ROAD. On its way from Erebus Crater to Victoria Crater, Opportunity encountered terrain consisting of large sand ripples and patches of flat-lying rock outcrops. Opportunity acquired images for this false-color mosaic April 8, 2006 (sol 748), at about 11:45 A.M. local Mars time. This view shows a portion of the outcrop named Bosque, fractured and finely layered outcrop rocks, smaller, dark cobbles littered across the surface, and rover wheel tracks. NASA/JPL-CALTECH/CORNELL

a rocky, dusty, and strangely familiar place. Because previous missions were successful, the current rovers had a firm foundation upon which to build.

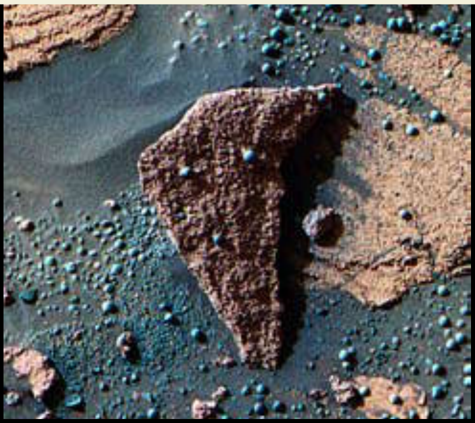
Jim Bell *is the leader of the Spirit and Opportunity Pancam color imaging team at Cornell University. His new book,* Postcards from Mars *(Dutton/Penguin Books, 2006), is now available.*

More than data acquisition

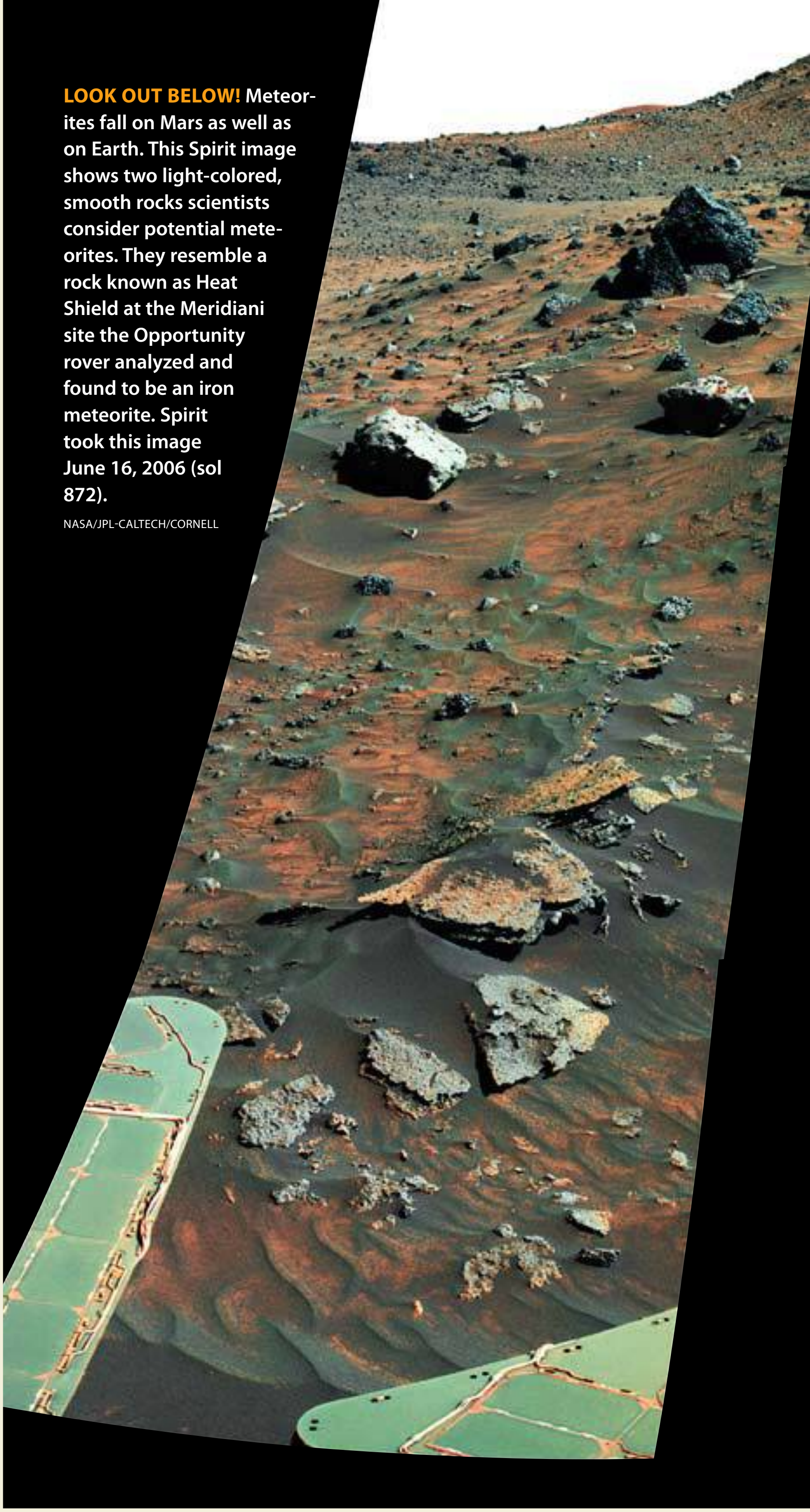
While Spirit and Opportunity scientists were not the first to see Mars' surface, they were the first to see the place in what is an ultimately more human way. The difference between the views of Mars from early missions and today's views is like the difference between the black-and-white television programs of the 1950s and today's high-definition television programming.



BUMPY BOULDER. As Spirit began collecting images for a new panorama, the rover captured this view of a dark boulder with a rough surface texture. The boulder sits about 16 inches (40 centimeters) tall on martian sand about 16 feet (5 meters) away from Spirit. This dark, volcanic rock fragment is pocked with holes called vesicles. Similar fragments litter the slope of Low Ridge. Spirit took this false-color image April 13, 2006 (sol 810). NASA/JPL-CALTECH/CORNELL/NMMNH



BLUEBERRY PIE. Opportunity took this false-color image from the rim of Eagle Crater in Meridiani Planum February 21, 2004 (sol 49). Dark, mysterious spherules called blueberries and an outcrop rock shard, fancifully named Shark's Tooth, dominate the image. NASA/JPL/CORNELL



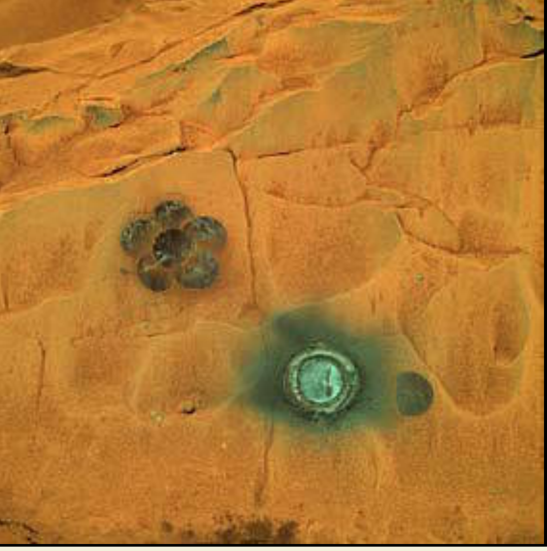
LOOK OUT BELOW! Meteorites fall on Mars as well as on Earth. This Spirit image shows two light-colored, smooth rocks scientists consider potential meteorites. They resemble a rock known as Heat Shield at the Meridiani site the Opportunity rover analyzed and found to be an iron meteorite. Spirit took this image June 16, 2006 (sol 872).

NASA/JPL-CALTECH/CORNELL

Spacecraft are complex and sometimes prove finicky to operate, so it's not easy to acquire images or send them home. Imaging time is often a scarce commodity shared among many different instruments and interests, and sometimes mission revisions occur in real time. Even more scarce, usually, is the bandwidth necessary to transmit high-quality images home. Power and onboard data storage are limited.

Merging art and science

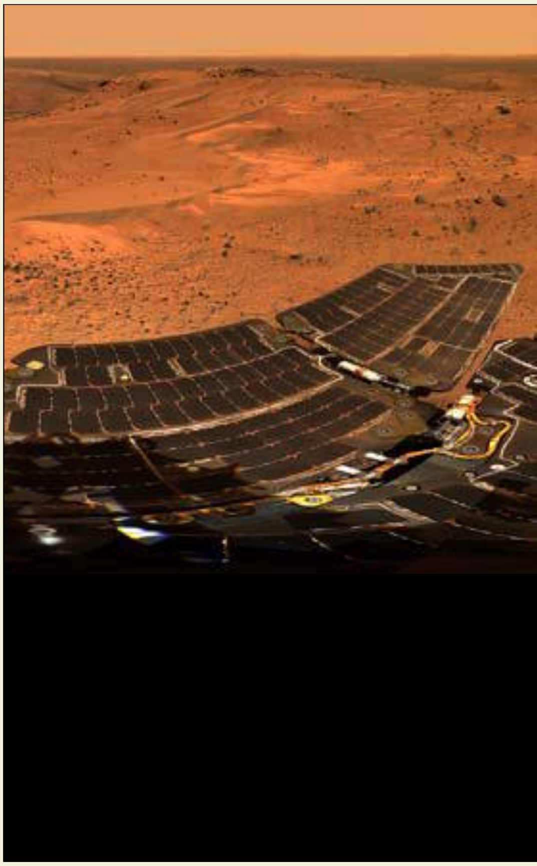
Those of us who take photographs with the rovers, however, have enjoyed three luxuries: more time devoted to picture-taking, higher bandwidth, and better camera resolution. These advantages allowed us to act like real photographers — even artists — while at the same time gathering all of the scientific and engineering information needed to run the missions.



WHAT A GRIND. Grinding the rock Mazatzal is slow when the work is directed from millions of miles away. This image shows marks from Spirit's Rock Abrasion Tool (RAT). The RAT drilled the hole, called "New York," 0.15 inch (3.8 millimeters) deep. A flower-shape group of marks from the RAT's brush appears to the hole's upper left. Another brush mark, dubbed "Illinois," sits to the right. Spirit's panoramic camera took this image of the rock Mazatzal April 1, 2004 (sol 86). NASA/JPL/CORNELL

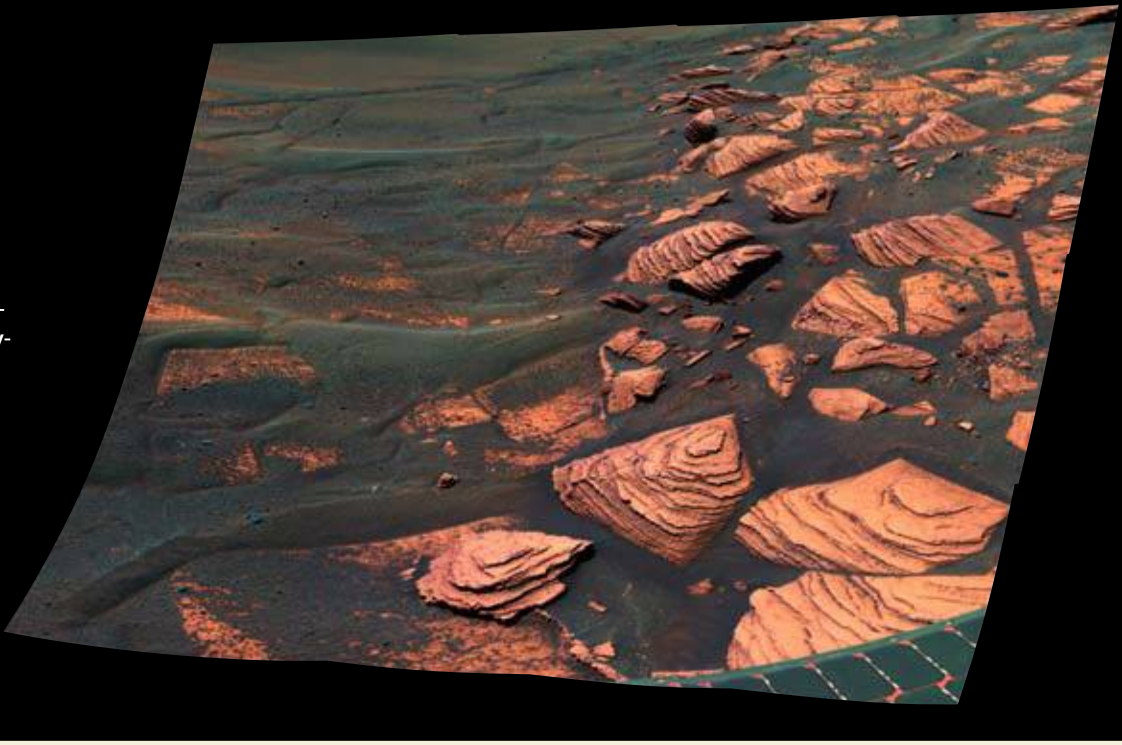
COLORFUL ROCK. Spirit's panoramic camera took this false-color image June 13, 2005 (sol 514). It shows an ancient, wind-etched rock perched on the flanks of Husband Hill near Spirit's landing site in Gusev Crater. NASA/JPL/CORNELL

STACKED DECK. This stack of fine rock layers exposed at a ledge called Payson on the western edge of Erebus Crater in Mars' Meridiani Planum shows a diverse range of primary and secondary sedimentary textures formed billions of years ago. These structures likely resulted from an interplay between windblown and water-involved processes. Opportunity took the exposures for this approximately true-color image March 3, 2006 (sol 749). NASA/JPL/CORNELL

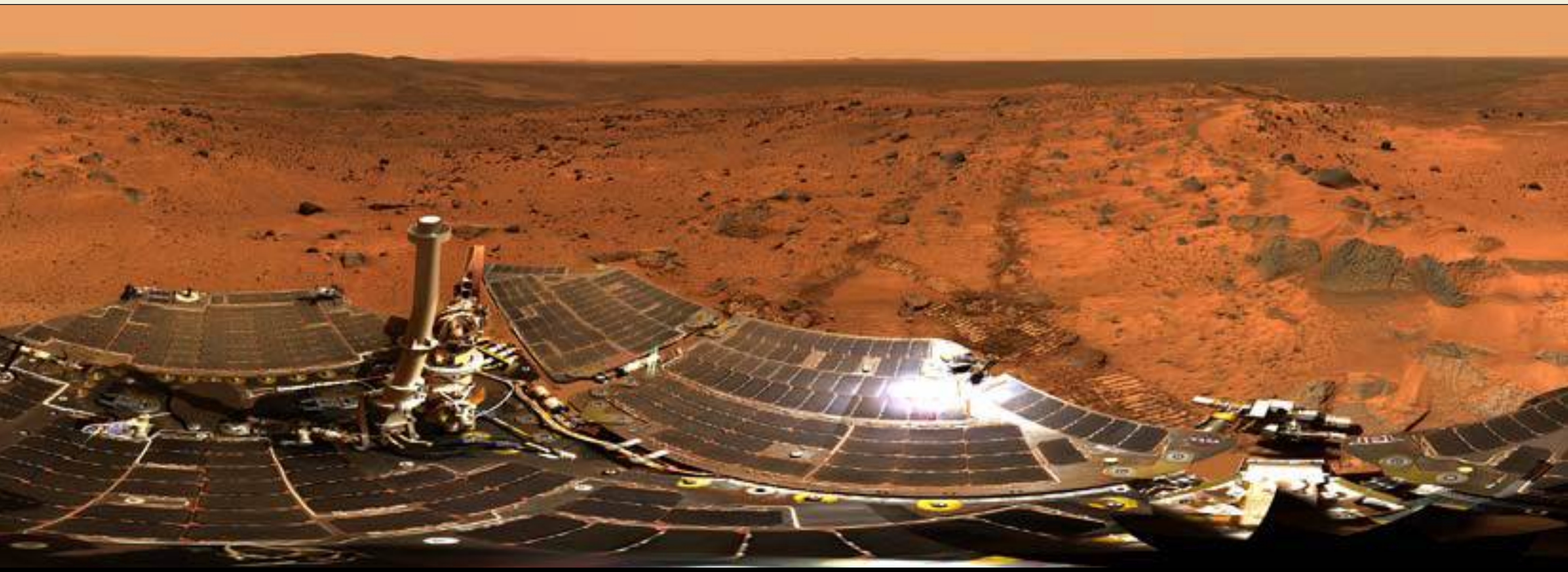


When designing a sequence for the Panoramic Camera Imaging System, I sometimes have the luxury to think about the same kinds of issues earthbound photographers consider in their quests to capture the spirit and stories of the land: Does this photograph have the potential to be particularly evocative, historic, or artistic? How can we frame this particular shot? Can we include some foreground rocks or rover parts in the image to give the view a sense of depth? What is the balance of sky and ground? And how do I interpret the view later, in the computer "darkroom," where I process the images?

As a child, landscape photography fascinated me. I loved the interplay of light and shadow in the environment and the way a photograph could be composed — like a musical piece — to tell the viewer a story in a certain way. I went to the



SO MANY CHOICES. Opportunity obtained this image of layered outcrop rocks just south of Erebus Crater with its panoramic camera February 18, 2006 (sol 758). Mission scientists employed false-color imaging to conduct mineral analysis. NASA/JPL/CORNELL



JIGSAW PUZZLE. Spirit's panoramic camera took hundreds of images scientists combined into this 360° view called the Husband Hill Summit panorama. This is the largest panorama yet acquired from either Spirit or Opportunity — 653 separate images in 6 different filters. It encompasses the rover's deck and 360° of surface rocks and soils visible to the camera. Stitching together the images took significant effort because of the large changes in resolution and parallax (displacement caused by different camera positions) across the scene. Spirit acquired the images August 24–27, 2005 (sols 583 to 586), shortly after the rover reached the crest of Husband Hill inside Gusev Crater. NASA/JPL-CALTECH/CORNELL

library and soaked up books about 19th- and 20th-century landscape photographers, and it's been my lifelong hobby. Little did I realize I'd have the opportunity to help take some of the most spectacular space-landscape photographs ever made.

My goal — and that of the entire rover team — is to share the beauty, desolation, grandeur, and sometimes alien strangeness of Mars the rover cameras reveal. Many of these images are, I believe, the closest representations yet made showing what it must be like to be there, standing on Mars.

Someday humans will stand on Mars. Until then, these portraits from mechanical tourists will have to suffice. A

ONLINE EXTRA See more great portraits sent back by Spirit and Opportunity at www.astronomy.com/toc.

THE SKY IN DEPTH No. 7

A supernova blast seen in 1054 continues to shed light on stellar evolution. /// **BY RAYMOND SHUBINSKI**

All about the Crab Nebula

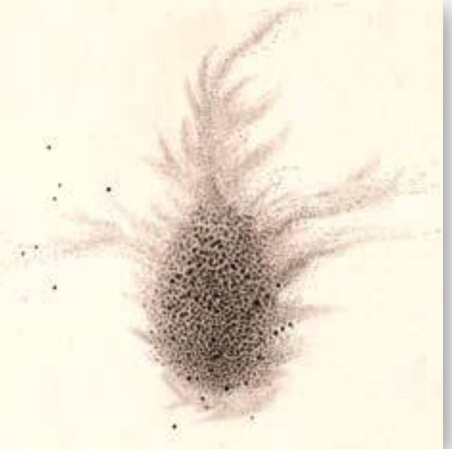
At the core of the Crab Nebula (M1) lies a monster of such demonic proportions the human mind can barely fathom its true nature. The heart of this expanding maelstrom contains a spinning object which, a few generations ago, would have been classified as science fiction.

The heart of this monster beats 33 times a second and rips normal matter to shreds by its mere proximity.

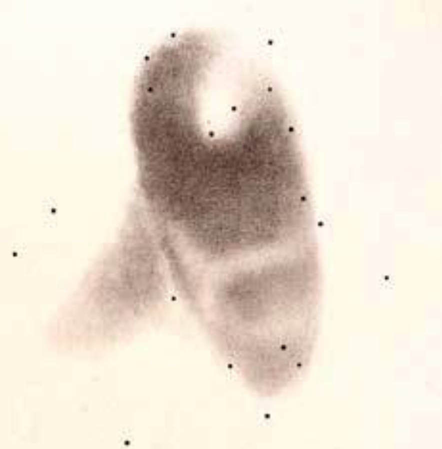
Science only guessed at the presence of this beast until 1967. In that year, a young astronomy graduate student at Cambridge University in England named Jocelyn Bell (now Jocelyn Bell Burnell) detected a pulsation coming from the constellation Taurus. Every day, the pulsation appeared about 4 minutes earlier. Because astronomers could tie a 4-minute variation to Earth's orbit around the Sun, this clearly marked the source as stellar. The pulsations — 33 times each second — were so regular astronomers playfully dubbed them LGM, or Little Green Men. What could be the source of such a regular beat? No known natural explanation was at hand.

Deciphering the mystery

In the 1960s, the study of stellar evolution was making great headway. Efforts were under way to explain how stars of different masses end their lives. Stars of about 1 solar-mass, like our Sun, would gently blow off about 50 percent of their mass into space. Gravity would pull the star's remaining mass back, forming a white dwarf — a tight sphere about the size of Earth.



WILLIAM PARSONS, the third earl of Rosse (1800–1867), published the first sketch of the Crab Nebula in 1844. This sketch gave rise to the name "Crab." Parsons used a 36-inch reflecting telescope he constructed at Birr Castle, Ireland. LINDA HALL LIBRARY OF SCIENCE, ENGINEERING, AND TECHNOLOGY



THROUGH A 72-INCH telescope, the Crab Nebula looked like this to R. J. Mitchell when he made this 1855 sketch. Mitchell, an observatory assistant to Parsons, used the 72-inch reflector (called the Leviathan of Parsonstown) at Birr Castle. LINDA HALL LIBRARY OF SCIENCE, ENGINEERING, AND TECHNOLOGY

THINK SUPERNOVAE ARE A BLAST?

Check out these stories on exploding stars from the pages of *Astronomy*:

- "Live fast, die young" — April 2006
- "Do we live in a cosmic shooting gallery?" — November 2005
- "The star-splitting jets of supernovae" — October 2004

Study one aftermath of a supernova:

- "What makes a black hole tick?" — October 2005

Read about a famous nova:

- "Ready, set, boom!" — September 2005

View some supernova remnants through your telescope:

- "How to observe exploded stars" — September 2006

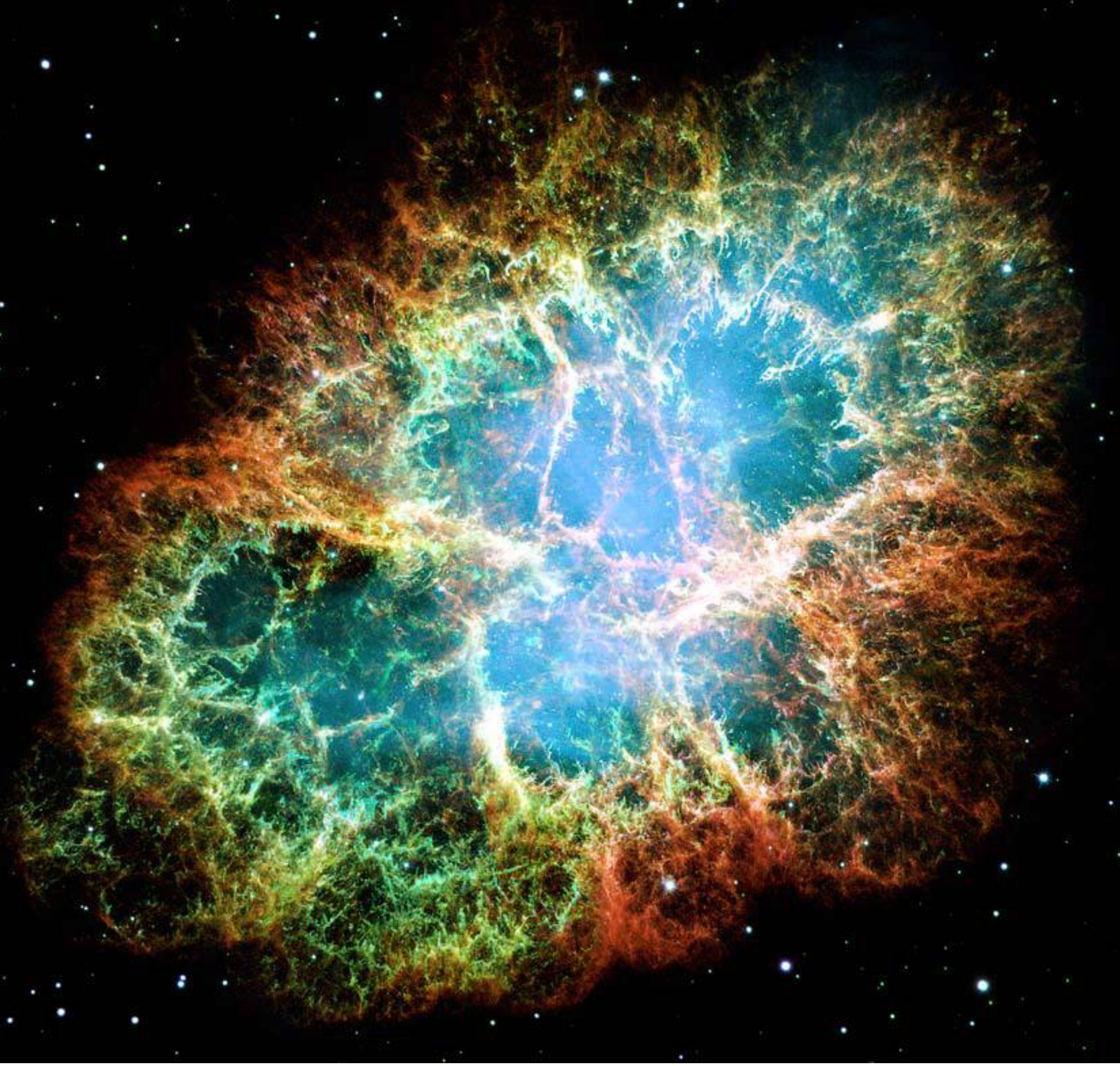
Stars of 8 solar-masses or greater end their lives differently — and explosively. As these stars reach a critical stage, their cores collapse under the force of gravity only to rebound in tremendous explosions known as supernovae. Gravity compresses whatever mass isn't blown into space into a sphere only a few miles in diameter. The matter in this stellar remnant is crushed until it's packed as tightly as an atom's nucleus, which finally stops the collapse. This object, known as a neutron star, spins at a tremendous speed.

The pulsing Bell detected was a beam of radiation from the star's surface. As the star rotated, the beam swung by Earth's field of view. Astronomers call such objects pulsars. The pulsar's spin produces a regular beat more accurate than any clock.

This was not the end of the story, however. The pulsar happens to lie near the star Zeta (ζ) Tauri. When astronomers pinned

---

Raymond Shubinski *is the director of Science City/Attractions in Kansas City, Missouri.*



THE CRAB NEBULA (M1) became visible in 1054 A.D. as a "new" star astronomers now call a supernova. Measurements show material from this explosion expands at 3.3 million mph (5.3 million km/h). To make this composite image, NASA assembled 24 individual exposures taken with the Hubble Space Telescope's Wide Field and Planetary Camera. NASA/ESA/J. HESTER AND A. LOLL (ARIZONA STATE UNIVERSITY)

down its location, they identified the pulsar as the star at the Crab Nebula's center.

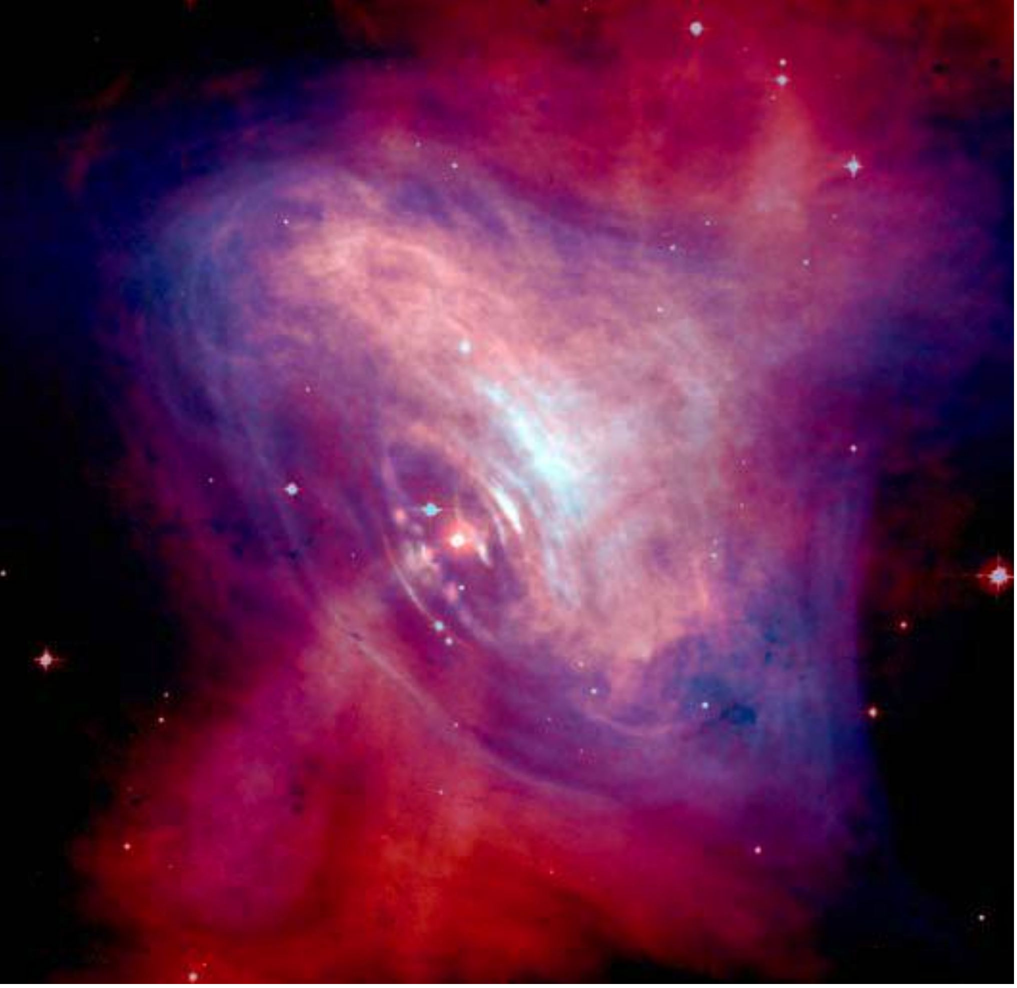
In the wake of such a stellar cataclysm, the gas expanding into space is rich in heavy elements — elements created only by supernovae. What occurred in the sky in 1054 was not just the death of a star, but the enrichment of space that may lead to the building blocks of new planets, perhaps planets like Earth.

Enter the comet-hunter

Three hundred and fifty-eight years before Bell's discovery, Dutch spectacle-maker Hans Lippershey (1570–1619) combined a few lenses and invented the telescope. In 1610, Italian scientist Galileo Galilei (1564–1642) turned this new device on the heavens and changed how we view our universe.

Galileo discovered the Milky Way is made of millions of stars too faint for the eye alone to see, and that some areas, such as the one in Orion's "sword," appear fuzzy. These fuzzy patches intrigued the new breed of telescope-using astronomers. As telescopes improved, so did observations.

In the 18th century, astronomers began to meticulously catalog their discoveries. One of the most famous of these observers was Frenchman Charles Messier (1730–1817). At the age of 14, Messier saw a



THIS COMPOSITE **combines exposures in X-ray (blue) and visible (red) light. The X-ray image is smaller because the electrons emitting X rays radiate away their energy more quickly than the lower-energy electrons emitting visible light.** NASA/CXC/HST/J. HESTER ET AL.

QUICK TAKES ABOUT THE CRAB NEBULA

OBJECT TYPE: Supernova remnant

OTHER NAMES: M1, NGC 1952, CM Tauri

CONSTELLATION: Taurus

RIGHT ASCENSION (2000.0): 5h35m

DECLINATION (2000.0): 22°01'

SIZE: 6' by 4'

MAGNITUDE: 8.4

APPROXIMATE DISTANCE: 6,000 light-years

comet that thrilled all of Europe. In 1744, comets still were viewed with a mixture of wonder, suspicion, and fear.

English astronomer Edmund Halley (1656–1742) observed a bright comet in 1682 and concluded the comet — which now bears his name — would return in approximately 76 years. His claims made comet-hunting an absolute passion throughout the 18th century. After seeing the comet of 1744, young Messier soon became addicted to the search. From the start, however, he had problems. Messier kept finding fuzzy patches of light that looked like comets but refused to move against the background stars like comets.

Messier catalogs his first object

In spring 1758, Messier was hunting for a comet near the star Zeta Tauri, a star representing the tip of one of Taurus the Bull's horns. Messier thought he had found a new comet, but the object refused to move. Messier decided to start a catalog of these "non-comets," and he made this object in Taurus the first on his list — M1.

Although this object became the first in Messier's now famous catalog, he was not the first to observe it. That honor goes to Englishman John Bevis (1693–1771), who glimpsed this faint speck of light in 1731.

Even with the ever-present animosity between England and France, Messier generously acknowledged the discovery by Bevis in a later edition of the catalog. Little did either imagine he was not the first to see M1's light and that, one day, it would enhance our understanding of the stars.

A new star blazes forth

The year 1054 was difficult for Pope Leo IX. In that year, Leo excommunicated the Patriarch of Constantinople and created the split between the Eastern (afterward called Orthodox) and Western churches. Historians now call this event the Great Schism of 1054. Leo died April 19, and, as if in response, less than 3 months later (July 4) a spectacular event blazed forth from the heavens. Europeans must have been busy with their own problems because no one seems to have noted this event.

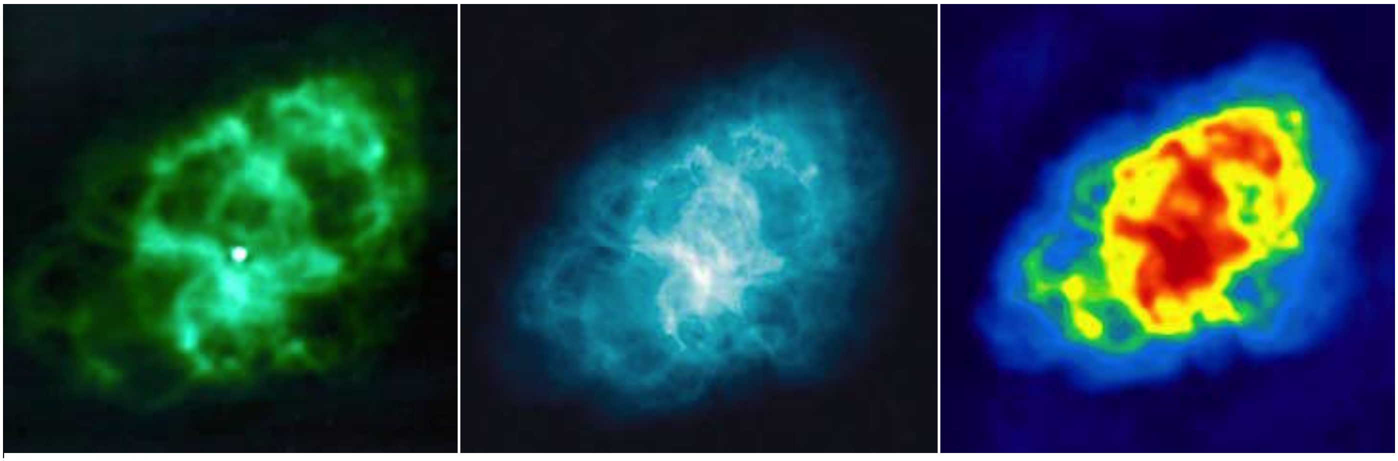
Half a world away in the Arizona desert, some Native Americans looked skyward the night of July 4 and were struck with amazement. There, near the crescent Moon, shone a new star 4 times brighter than Venus. The star could be seen in broad daylight for 23 days, and it took 653 days before it, at last, faded from view.

Generally known as the Anasazi, these skywatchers carefully noted the position of the bright new star with regard to the Moon. They had no written language, so they left their records in petroglyphs on an overhanging rock face sheltered from the weather. Astronomer Carl Sagan sums up the situation beautifully: "The position relative to the crescent Moon would have been just as it was depicted. There is also a handprint, perhaps the artist's signature."

Strangely, like the Europeans, Arabs left almost no record of this event. One reason may have been that, for these skywatchers, planetary positions relative to bright stars were far more important than transient events for making astrological predictions. One culture, however, left detailed records of this startling event.

This strange "guest star" entranced the Chinese. The need for astrological interpretations drove their astronomy. Being an astrologer in the court of the Sung emperor was a deadly serious business. Astrologers carefully tracked comets and even left records of naked-eye sunspots. They predicted solar and lunar eclipses, and noted many guest stars. The guest star of 1054, however, received special attention.

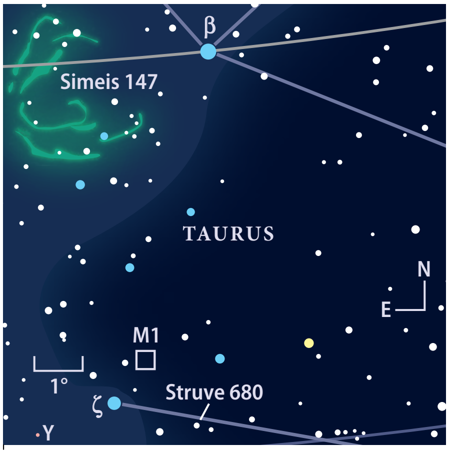
Chinese astronomers first observed the guest star near the star T'ien-kuan, known to us as Zeta Tauri. The new star that had


NRAO/AUI

RADIO-TELESCOPE false-color images of the Crab Nebula show different details, depending on the wavelengths sampled. In the left image, we can see the bright pulsar (centered) formed from the supernova explosion. The center image shows plasma waves moving out from the pulsar at half the speed of light. The right image is a combination of the other two images.

split the heavens open caused the emperor great anxiety. Finally, astrologer Yang Wei-te appeared before the emperor with this report: The guest star "does not trespass against Pi, the lunar mansion in Taurus, and its brightness is full meaning that there is a person of great wisdom and virtue in the country." It sounds like Yang Wei-te was reading fortune cookies, but what would *you* tell the emperor?

The guest star that first appeared July 4, 1054, faded from view April 17, 1056, and also faded from human memory except for these few records. There were other guest stars seen through the centuries, one of which Tycho Brahe (1546–1601) observed in 1572. Tycho, the ever-careful observer, proved this new star, like the comet of 1560, was far beyond the Moon and part of the realm of fixed stars. He even gave the event a name: *stella nova*, Latin for "new star."



USE THIS CHART to help you locate the Crab Nebula (M1) in the winter sky. M1 lies in Taurus the Bull, slightly more than 1° northwest of Zeta (ζ) Tauri, which marks the tip of Taurus' southern horn. Even a 3-inch telescope reveals the Crab as a misty, magnitude 8.4 patch roughly 6' across. *ASTRONOMY*: RICHARD TALCOTT AND ROEN KELLY

Lord Rosse draws the Crab

Because of a high percentage of cloud cover, Ireland doesn't rank highly for astronomy. In the mid-19th century, however, William Parsons, third earl of Rosse (1800–1867), made the best of his situation. At his ancestral home, Birr Castle, he erected a reflecting telescope with a 36-inch (91 centimeters) mirror. Parsons excelled at drawing what he saw in the eyepiece. In 1844, he observed M1 and made some notes: "We see resolvable filaments singularly disposed, springing principally from its southern extremity, and not, as is usual in clusters, irregularly in all directions."

The drawing of M1 looked rather like a beach crab, and the object soon came to be known as the Crab Nebula. By 1848, Parsons was observing the Crab Nebula with the Leviathan of Parsonstown, a 72-inch reflector that gave even better views of M1, but no hint as to its true nature.

English astronomer William Herschel (1738–1822) thought M1 could be resolved into stars if only he used a large enough telescope. Lord Rosse thought he could see individual stars. He was incorrect. Telescopes alone, no matter how large, could not resolve the debate. It would take a new instrument to unravel this mystery.

Seeing M1 in a new light

English astronomer William Huggins (1824–1910) attached a spectroscope to his telescope and revealed a new way of viewing celestial objects. A spectroscope separates starlight into a rainbow of color broken by dark lines. In the mid-19th century, astronomers were just beginning to understand how to decipher these celestial bar codes. Later spectra revealed much about the Crab Nebula, including its chemical composition and its expansion speed.

At the turn of the 20th century, Vesto M. Slipher (1875–1969) became director of Lowell Observatory in Flagstaff, Arizona. Slipher mastered spectroscopy. He found M1's spectral lines indicated the nebula was expanding fast. Today, we know the gas travels outward at 3.3 million mph (5.4 million kilometers per hour).

Images taken decades apart show the Crab Nebula changing over time. Further studies placed the Crab about 6,000 light-years away. It engulfs an area of space greater than 10 light-years across.

The first thing astronomers wanted to know was when this expansion began. Images of M1 taken with the 100-inch Hooker Telescope at Mt. Wilson in California indicated an age of about 800 years. This was not quite on the mark, but no one knew they were looking for the guest star of 1054 until Bell's discovery of the Crab pulsar pointed the way.

Each advance in telescope or detector technology leads to new discoveries about M1. If you have the chance to observe the Crab Nebula, you'll see the remnants of a great explosion and part of the reason Messier's first object continues to astound astronomers. **A**

ONLINE EXTRA Watch a movie of the Crab pulsar at www.astronomy.com/toc.

THE ULTIMATE IN ASTRO SHOPPING:
www.adorama.com

PREMIER SELECT CELESTRON DEALER

CPC Series
XLT Starbright H.P. Schmidt Cassegrain Telescope with NexStar Computer Control & SKyAlign Technology

Tomorrow's next generation 8, 9.25, and 11 computerized GPS SCT's are here now!

NexStar SE

NEW! Nexstar SE Series
4SE, 5SE, 6SE, 8SE,
INCLUDES:
- XLT Coatings
- Orange Removable OTA,
- 40,000 object database,
- Nexstar Remote Software,
- The Sky Software
- Adjustable Tripod

SkyAlign
Easy as 1 - 2 - 3!
USE NEARLY ANY 3 BRIGHT OBJECTS IN THE SKY TO ALIGN YOUR TELESCOPE!

STARTING AT
$599.00

CGE-1400, 14" Schmidt-Cassegrain Telescope with XLT Coatings & CGE German Equatorial Mount

- 14" (356mm) Schmidt-Cassegrain Optical Design
- 3910mm Focal Length, f/11
- StarBright Multi-Coating
- XLT Coating Optional
- Computerized Equatorial Mount
- 40,000+ object database with 400 user-defined objects. CompassCalibration, Polar Alignment routine, Auto North and Level, Quick Align.
- Super HD Tripod
- Computerized Hand Control
- RS-232 communication port on hand control
- Optical Tube Weight - 45 lb.
- Tripod/Mount Weight - 139 lb.

CELESTRON TELESCOPE ACCESSORIES

NexImage
Solar System Imager
NEXIMAGE ACCESSORIES

UV/IR CUT OFF Filter 52.95
Neximage Reducer 21.95
2x Ultima Barllow Lens 60.95

$99.95

EYEPIECES KITS

Includes: • 5 Superior Grade Plossl Eyepieces 1.25"(4mm, 6mm, 9mm, 15mm, & 32mm), • 2x Barlow Lens, • Six Colored Filters, • Moon Filter, • Aluminum Carrying Case
All for only $129.95

2" ACCESSORY KIT
Includes: • 3-2" Eyepieces, 2" 5 Color Filters, 2"Star Dia, 2" 2X Barlow Aluminum Case $239.95

CELESTRON DAY

Sunday December 3
Meet The Rep
(Door Prizes)

CHECK OUT THE NEW SKYSCOUT (DEMO)

CELESTRON SKYSCOUT

SKYSCOUT PERSONAL PLANETARIUM

Introducing the SkyScout from Celestron:
The SkyScout is a revolutionary, one of a kind, patented handheld device that instantly identifies and/or locates any celestial object visible to the naked eye, providing educational and entertaining information, both in text and audio.

A fun learning tool for all ages, the SkyScout personal planetarium puts the knowledge of an expert astronomer in the palm of your hand.

Item Includes: Carry Case, Earphones, Hand Strap, USB Cable $399.95

ADORAMA INC.
Source for the **Educated Photographer**

HomeDome/ProDome

PD15 in New Jersey

- True Rotating Dome
- Easy Assembly
- 6, 10, 15ft. Diameter
- All Fiberglass
- Motors & Automation
- Wide Slot Openings
- Complete Systems Priced from $2990

ROBOFOCUS™
Automated Focus Driver
with temperature compensation
$425

Technical Innovations, Inc.
7851 Cessna Ave.
Gaithersburg, MD 20879
Ph: 301-977-9000 • Fax: 301-977-1106

FREE BROCHURE
www.homedome.com • www.robofocus.com

Swinburne Astronomy Online

Online Courses in Astronomy:
Designed for amateur astronomers, science educators, and anyone with a love of astronomy, Swinburne Astronomy Online is interactive astronomy education featuring custom-made CD-ROMs, newsgroup discussions and informed commentary on the latest astronomy headlines.

Programs:
We offer Master of Science in Astronomy and Graduate Diploma of Science in Astronomy programs, individual unit enrollment and a six-week short course, all online and accessible worldwide.
Visit: **www.astronomy.swin.edu.au/sao/shortcourse**

SWIN BUR NE
CENTRE FOR ASTROPHYSICS AND SUPERCOMPUTING

For more information, visit www.astronomy.swin.edu.au or contact Dr. Sarah Maddison at:
email: astro@swin.edu.au **fax:** +61-3 9214-8797
airmail: H39, Swinburne University of Technology,
PO Box 218, Hawthorn VIC 3122 Australia

33525

riverscamera.com

MEADE Accessory Headquarters

DEEP SKY IMAGER II
$599.95
Phone or Web
Free Shipping

NEW Meade LX200R's In Stock

SERIES 5000 Ultra Wide Angle Eyepiece
In Stock / Free Shipping

We know MEADE RCX Telescopes.
Factory-trained staff members. Call Us!

TeleVue® Factory Authorized DEALER
All TeleVue Eyepieces in stock

Scope Armor protective cover for telescopes

CELESTRON®

New SkyAlign Alignment Technology
Fast, easy alignment.
Simply choose three bright stars.
Telescope does the rest. CPC800
$1899.00 + $95 s+h.

NEW! Celestron SkyScout
Revolutionary handheld device, GPS technology. Point and click to instantly identify stars & planets visible to naked eye. Includes audio/text facts & trivia about our most popular celestial objects.
SkyScout Personal Planetarium $399.00 + s+h.

Nikon • Canon • Pentax • Sony • Leica
Olympus • Kowa • Bushnell • Kendrick
JMI Accessories • ScopeTronix Accessories
Telrad • Losmandy • Vixen Products
Coronado • Large Book Selection
- One of the Largest Binocular and Telescope Displays in the East
- Mail-Order or In-Store • No Sales Tax!
- Used Scopes — Buy, Sell or Trade-In
- Knowledgeable, Personalized Service

MONEY BACK 100% Satisfaction GUARANTEE

Rivers CAMERA AND TELESCOPE

Customer Service: *See Fred's Story on our Website!*

Toll-Free (800)245-7963
www.riverscamera.com
454 Central Ave., Dover, NH 03820 Fax: (603) 742-5456

Chris Emer
Astronomy Expert

M-W 8:30-6
Th. 8:30-7
Fri. 8:30-6
Sat. 9:30-5

optcorp.com

HO! HO! HO!

Get a belly full of savings at OPT

When you're shopping for gifts this holiday season, why look anywhere else?

MEADE
Telescopes for the serious astronomer!

CELESTRON
Astronomy made easier!

TeleVue Visionary
Enhance your viewing pleasure!

SBIG ASTRONOMICAL INSTRUMENTS
The imaging company!

CORONADO
Safe affordable solar viewing!

PENTAX
Imagine the difference!

"I do all my holiday shopping at OPT."
SC, North Pole

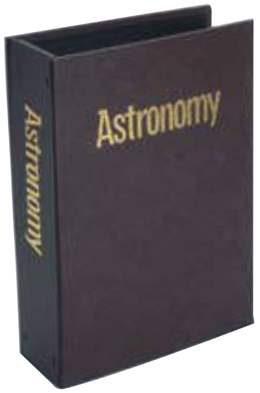
For Binoculars this Season, visit www.optbinoculars.com

Exclusive dealers for: AstroDude, DewBuster, ImagesPlus, Mitty Evolution Wedges, Pentax and SolarScope

Proudly Representing:
Antares, Apogee, Astrodon, Astronomik, Astrosystems, AstroZap, Astrovid, Baader Planetarium, Bob's Knobs, Borg, BT Tech, Canon, CosmoComfort, Custom Scientific, Denkmeier, Finger Lakes Instruments, Hutech, JMI, Kendrick, Losmandy, Lumicon, Luminera, Lymax, Maxfactory, MaximDL, Optec, Orion, Parallax, Pier-tech, RC Optical, ScopeGuard, Software Bisque, Starbound, StarGPS, Starlight Instruments, StarryNight, Stellarvue, Takahashi, Telegizmos, Telrad, Unihedron, Vector, Vixen, William Optics, and Yankee Robotics

OPT
Oceanside Photo & Telescope • 800.483.6287
918 Mission Avenue • Oceanside, CA 92054

PROTECT YOUR INVESTMENT!



Preserve your library of Astronomy magazines with durable hardcover binders.

ITEM NO. 14007
1 for $13.95 • 3 for $38.95
5 for $59.95

Order yours today!

TO ORDER BY MAIL: Send your order to Kalmbach Publishing Co., Dept. A2002, 21027 Crossroads Circle, P.O. Box 986, Waukesha, WI 53187-0986. Use chart below for shipping & handling charges.

MERCHANDISE TOTAL	ADD
$15.00 or less	$4.95
$15.01–$30.00	$5.50
$30.01–$50.00	$6.50
$50.01–$75.00	$7.50
Over $75.00	$8.50

Canada add an additional $2.00, other foreign add an additional $5.00. For Wisconsin delivery, add 5% sales tax to total; for Pennsylvania delivery, add 6% sales tax to total. For delivery in Canada add 7% GST to total. Payable in U.S. funds. Checks must be drawn on a U.S. bank except for those from Canada; GST included. Make checks payable to Kalmbach Publishing Co. Prices and availability subject to change.

call 800-533-6644
Mon–Fri, 8:30am–5:00pm Central Time.
Outside the U.S. and Canada, call 262-796-8776.
Please have your credit card ready.

fax 262-796-1615

www astromagbooks.com
Secure online ordering available.

Astronomy

A30785AD A2002

Learn how to capture dazzling solar photos.

/// IMAGES AND TEXT BY GARY PALMER

Sun studio

This is an exciting time for imagers and observers of the Sun, with plenty of action to observe through the eyepiece of a solar scope. Interest in solar observing has rapidly grown through local astronomy clubs and at astronomy expos, and, for many, solar photography is the next step.

Preparation is the key to any successful imaging session. The Sun's active regions may flare up in seconds and disappear within minutes. Having a solid imaging setup helps capture these brief moments of the Sun's routine with captivating images of our closest star.

My window to the stars is in California's Santa Monica Mountains, located just 5 miles from the Pacific Ocean at an altitude of 800 feet (244 meters). A typical day for me begins well before our Sun breaks the horizon. I review the Sun's status online and then select active regions to focus on as the Sun begins its daily climb into the eastern sky.

GARY PALMER

How clear is it?

Earth's atmosphere may be the most important consideration when solar imaging. I perform 95 percent of my imaging at sunrise, after cooler overnight temperatures have allowed the previous day's heat to dissipate from the landmass. A transitory inversion layer — a cloud mass that gently pushes in off the Pacific Ocean and blankets the lowland coastal areas — makes for steadier skies here by effectively trapping stray light.

Last year, there were mornings when, just as I began my capturing sequence, I was completely engulfed in the white inversion layer that had pushed in and up off the Pacific Ocean. I've learned that a daily routine may not always produce quality images, often because of poor atmospheric conditions. I take those days in stride and, instead, focus on enhancing my solar-imaging process. The excitement in solar observing and imaging comes from

WHAT CAUSES THE SUN TO SHED SMALL AMOUNTS OF MASS?

Each second, the Sun sheds close to a million tons of matter that is carried away with the solar wind. Although that seems to be a tremendous amount of matter, the Sun has lost only 0.1 percent of its material since its formation 4.6 billion years ago. Two processes taking place in the Sun account for its mass loss: nuclear fusion and convection.

Nuclear fusion is the process by which the nuclei of lighter elements join to form heavier elements, thus releasing large amounts of energy. In the Sun's case, hydrogen nuclei join to form helium. Convection is the process by which the Sun transports energy created in the core to the surface, where energy is expelled in the form of light, heat, and high-energy particles. — *G. P.*

SUN FACTS

Age: 4.6 billion years

Mass: 98 percent of our solar system's mass (1.99 x 10^{30} kg)

Diameter: 218 Earth-widths at equator (6.96 x 10^{5} km)

Magnitude: –26.8

Luminosity: 3.9 x 10^{26} watts

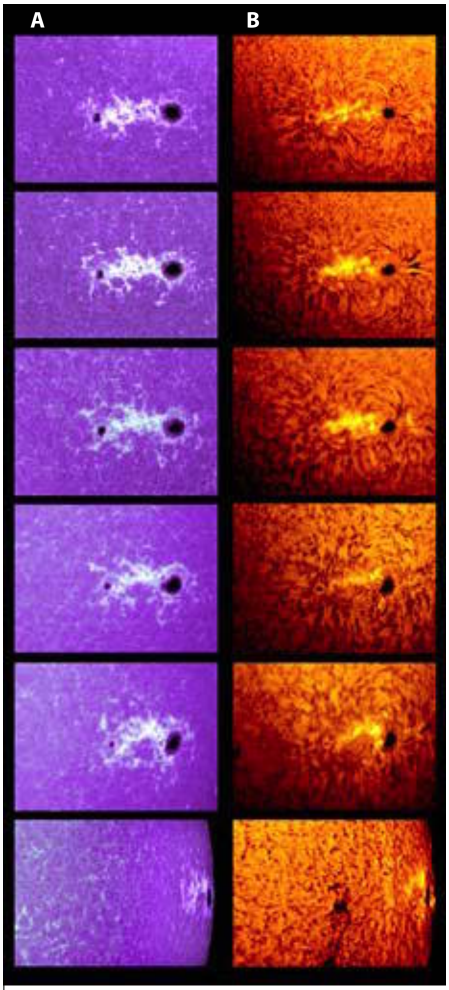
Rotational period: 25 days at equator, 36 days at poles

Surface temperature: 10,000° Fahrenheit (5,500° Celsius)

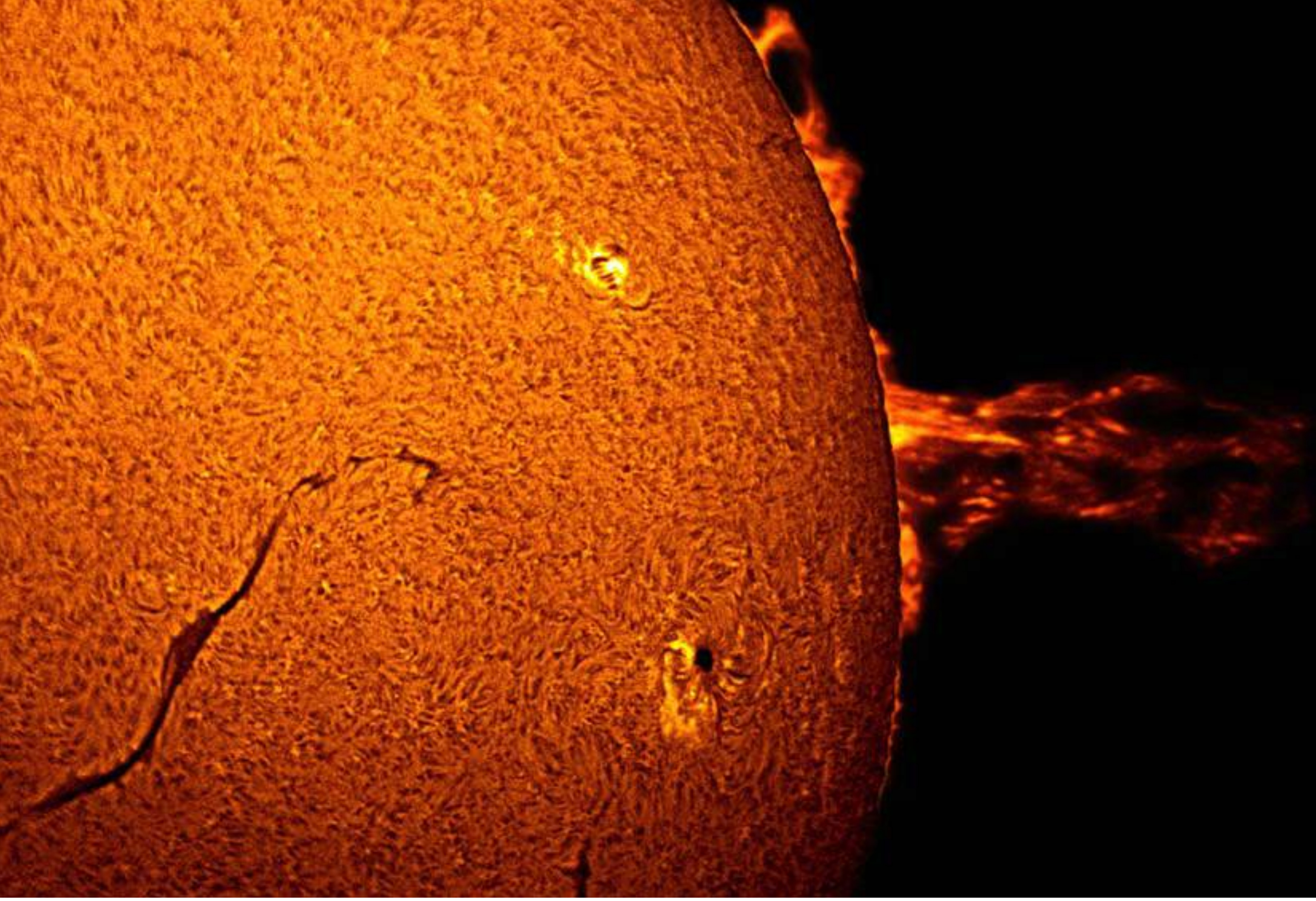
Core temperature: 28 million degrees F (15 million degrees C)

Composition: 90-percent hydrogen, 10-percent helium and other elements

Distance from Earth: 93 million miles (150 million kilometers, or 1 AU)



A: A CALCIUM K time sequence shows how a sunspot evolves over time.
B: A HYDROGEN-ALPHA time sequence shows the same sunspot evolution. Notice the difference in detail between the two sets.



HOT GASES ERUPT from the Sun's surface and are hurled into space. The solar wind carries away the stream of molten plasma, called a solar flare. Darker areas and circles called sunspots are cooler areas, while a multitude of spicules creates the Sun's hair-like texture.

never knowing what you're going to see or capture until you point the scope toward the Sun.

Cracking the solar-imaging code

I use a Canon G2 digital camera attached to a Coronado solar scope to image the Sun. The G2 is versatile, allowing me to select a black-and-white mode, set focus to infinity, manually adjust the shutter speed and f-stop, or image in a continuous-shooting mode. These features, along with a charge-coupled-device (CCD) chip that can cut through the highly saturated red glow of Hydrogen-alpha (Hα) light or the purple haze of Calcium K light, produce a crisp and detailed image of our Sun. This makes the Canon G2 attractive for solar imaging.

When using slower shutter speeds, the slightest camera vibration blurs an image. In continuous mode, the G2's shutter can't be triggered by the wireless remote. To steady the camera and make it as vibration-free as possible, I fabricated a bracket to attach a shutter-release cable. This keeps me from having to release the shutter manually, which is typically the main source of vibration.

Image-processing basics

First, capture as many images as possible in 10 minutes. With the shutter-release cable in continuous mode, I can capture 1.5 frames per second — a total of 15 frames in 10 seconds — before the camera needs to pause and write the data to the flash card. The 4-megapixel G2 camera's 512mg flash memory card stores about 500 images.

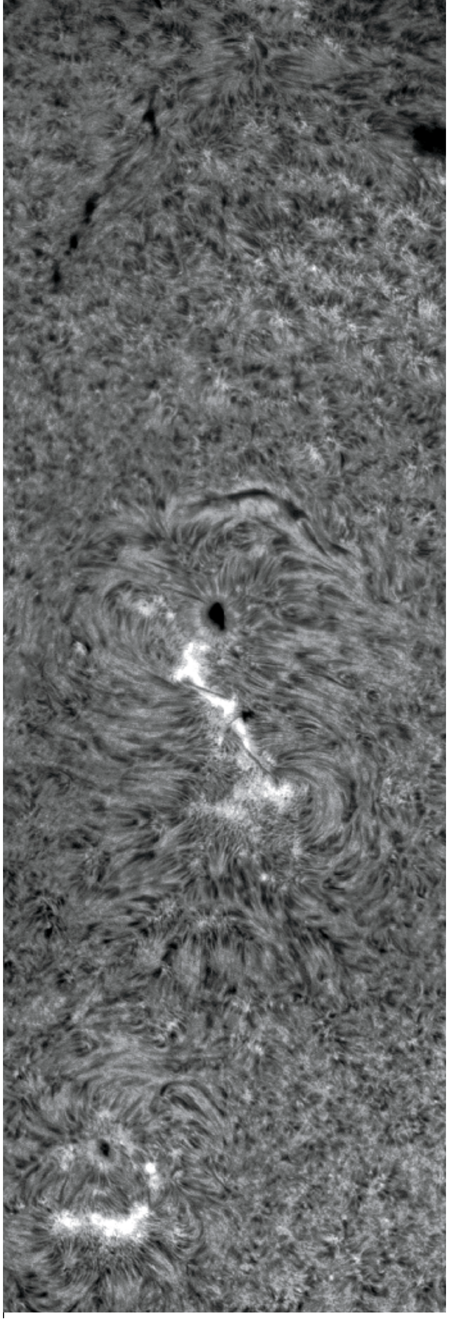
Edit and stack your captured images. Delete blurred or distorted images, and keep only the sharpest ones for stacking. I use *Keith's Image Stacker* software, available online at cs.unm.edu/~kwiley/software/keithsImageStacker.html, to accomplish this task. Editing cleans up individual images, and stacking the images combines the best parts of single frames to create a detailed composite.

Use the unsharp mask filter — both *Photoshop* and *Keith's Image Stacker* have this feature — to create a sharper image. Stack only the best frames, but use as many as you can acquire. How many quality frames you capture can range from two to 80 and depends on how steady the atmospheric conditions are. Each completed stack of images is unique, so experiment with sharpness levels to find the right amount for the effect you desire. Imagination and creativity make this task easier.

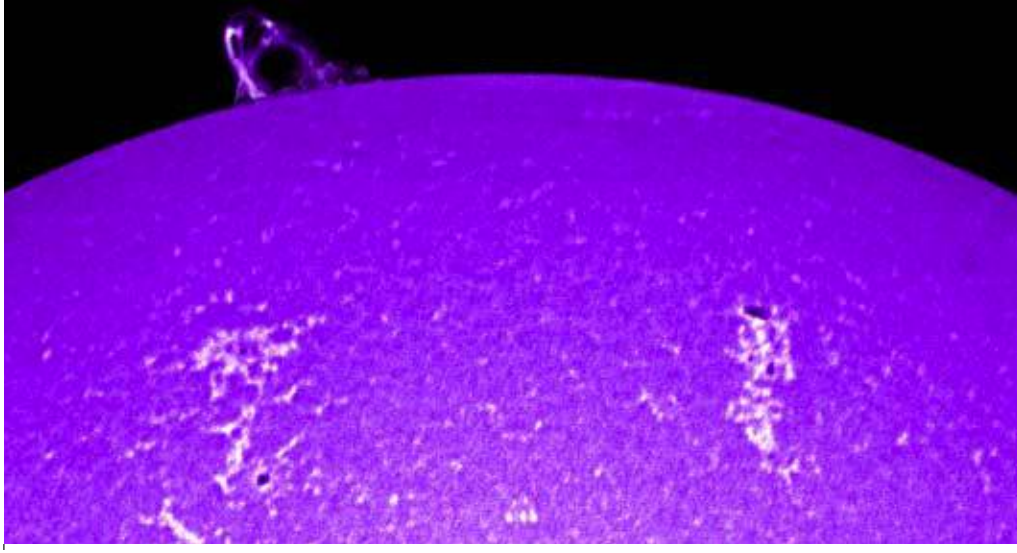
Don't stop with just one stacked set of images, either. Take a stacked, sharpened image and make several variations of it. Then, restack a new set of images to create a single image with even more depth.

Adjust contrast to enhance the image's depth and create a 3-D look. Similar to the unsharp mask filter, use the same technique with the histogram feature to create different

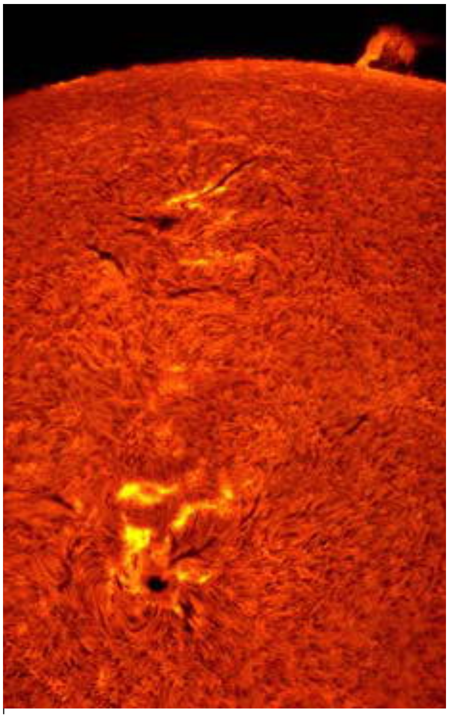
Gary Palmer *is a cinematographer, lighting designer, and solar photographer who lives in Los Angeles.*



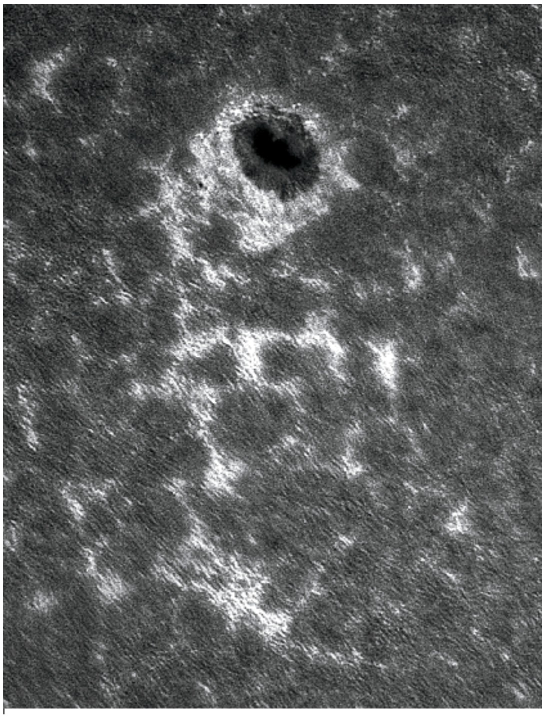
BRIGHT PLAGES surround dark sunspots.



A CORONAL LOOP bulges above the Sun's surface, connecting magnetic fields between sunspots.



HAIR-LIKE SPICULES cover the Sun's disk.



A SUNSPOT dominates this solar image.

A PURPLE HUE tells you you're looking at the Sun through a filter that lets only the Sun's Calcium K light (393.4 nm) pass through.

contrast variations of an image. Restack those images to create a new single image with more dimension.

Color balancing act

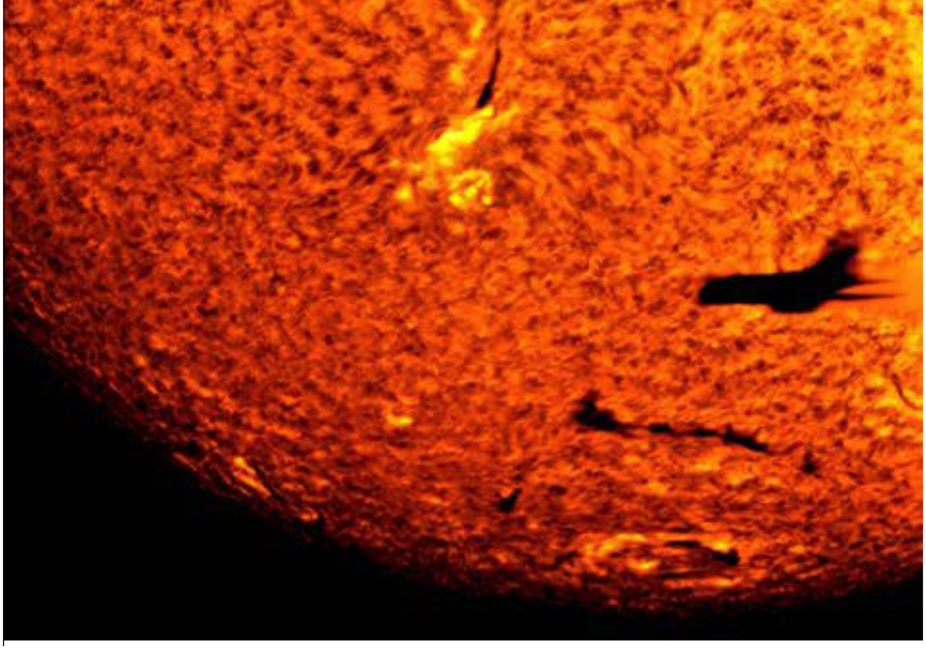
Balancing color is the most challenging aspect of image processing, and it can be the most fun. Everyone perceives colors differently. When I observe the Sun's Hα line (656.28 nanometers), I see a red-saturated Sun. With the Calcium K line (393.4 nm), I see deep purple.

When I asked Coronado co-founder Gerry Hogan what color the Sun should be, she quickly replied, "You're making art at this point; make the color of the Sun whatever you think it should be." I took her advice and added it to my imaging repertoire. Now, colors flow naturally from my palette.

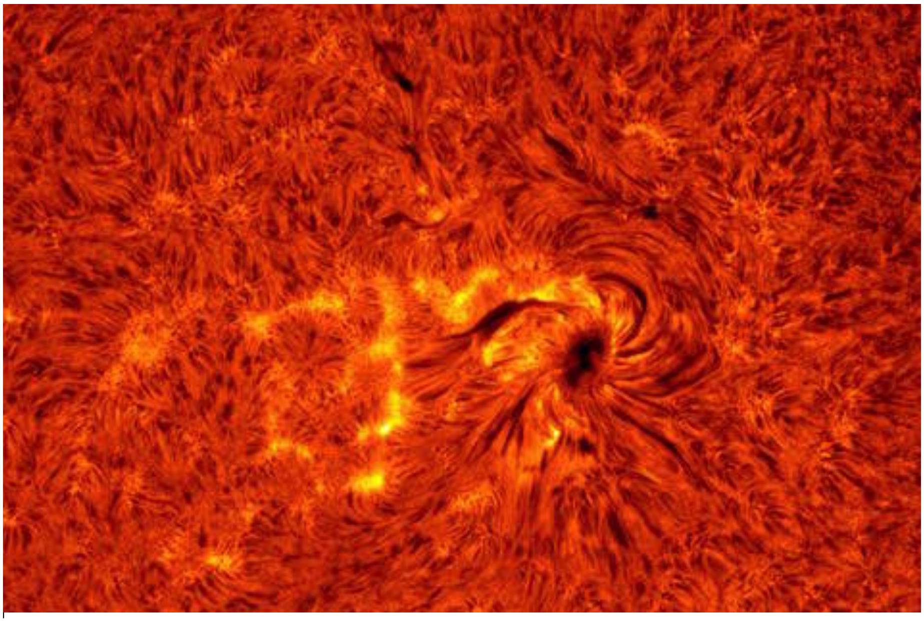
More resources exist on the Internet. If you have a question about solar imaging, the answer can likely be found online. Coronado's Solar Chat blog and Solar Chat archives offer many solar-imaging tips and tricks.

Patience is the most important characteristic needed to pursue solar imaging. The rewards you'll reap are a better understanding of the activity taking place on our closest star and spectacular images of the Sun's dynamic features.

The Sun offers near-daily opportunities to observe and image sunspots, solar flares, and other solar phenomena. All it takes is a solar telescope, a little bit of time, and some diligence. ▣



FILAMENTS appear as dark gashes across the Sun's disk. Note this shot's intervening airplane.



PLAGES AND SPICULES lie in a somewhat circular pattern around an oval sunspot.

HOW I CAUGHT THE SOLAR-IMAGING BUG

Photography for me was up front and center right from childhood. I enjoyed filming with my family's 8mm movie camera. Throughout high school, in Culver City, California, I continued to hone my craft as the yearbook photographer.

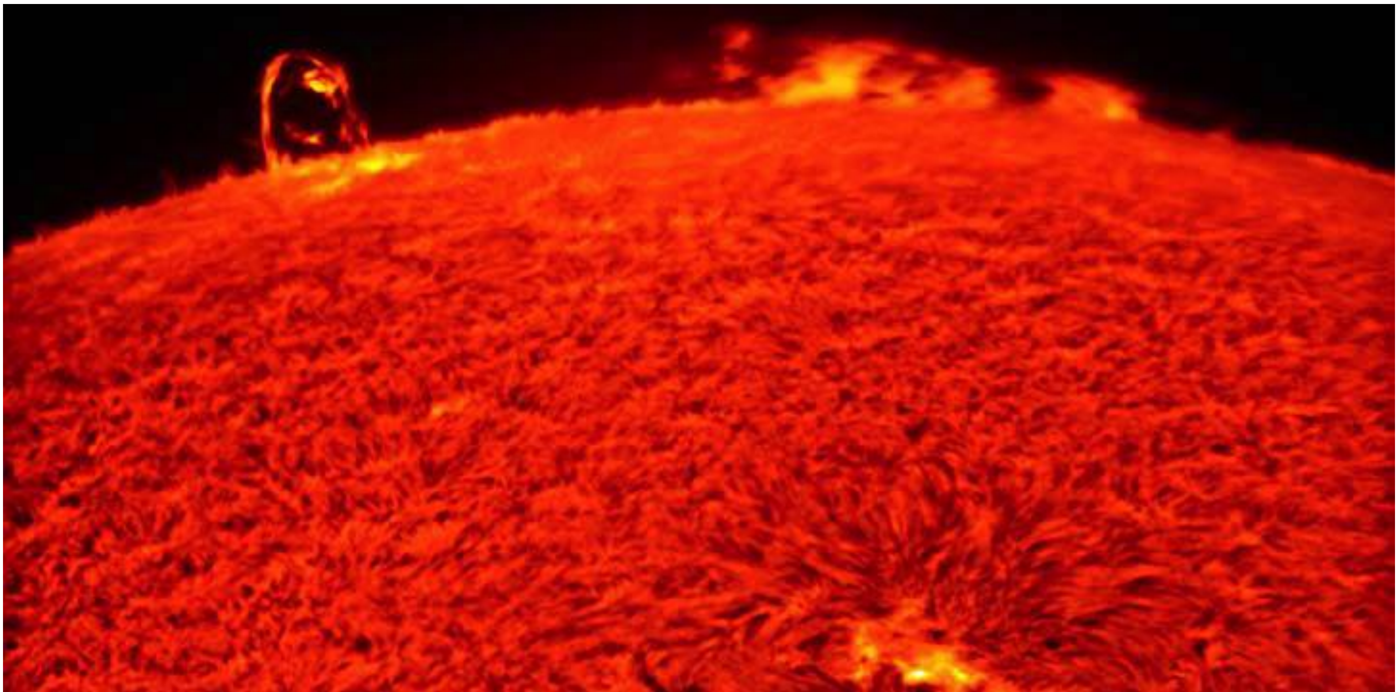
After I graduated from high school in 1973, I took off for the footlights and began my career in motion pictures at Paramount Pictures. As a lighting designer and cinematographer, I've enjoyed a 33-year career that's taken me around the world.

In January 1999, I was scheduled to photograph visual effects for the film *Mission to Mars*, but the film location changed, and I missed out on the opportunity. However, the experience piqued my interest in astronomy: I noticed photographing special effects is similar to astronomical imaging.

Photographing miniatures for motion-picture special effects is tedious work, and attention to detail is paramount. A single special-effects photo may be on the movie screen for only a second or two, but getting that shot can take several days. Similarly, creating one quality solar image can take several days of imaging.

For me, catching the solar-imaging bug has turned into a lifelong passion and led to a sense of connection. — *G. P.*

▼ **A CORONAL LOOP** (left) arcs above the Sun with prominences (right).



ASK ASTRO

Astronomy's editors and experts from around the globe answer your questions about the cosmos. This month: conservation laws and cosmic expansion, star birth, and occultations.

EXPANDING UNIVERSE

Q: How do the conservation laws of physics relate to the expansion and fate of the cosmos? — **LIDDY TRYON,** WALNUT CREEK, CALIFORNIA

A: A star's life cycle satisfies the conservation of energy law. Energy is released as nuclei fuse — this energy is turned into light and neutrinos — invisible, nearly massless particles that we are just learning to detect directly. While this energy escapes, it isn't lost. It just spreads over a larger volume.

Things become more complicated when you consider the expansion of the universe. Indeed, some "absolute" laws become less absolute. For example, today the observed temperature of the cosmic microwave background — the "echo" of the Big Bang — is very low, just a few degrees above absolute zero. The light that makes up this background comprises low-energy photons.

Yet, many billions of years ago, those same photons had much higher energies. Where did that energy go? The common explanation is that as the universe expanded, it "stretched" the light's wavelength, reducing its energy. If you think this is a roundabout way of violating conservation of energy, you are correct. **In Einstein's theory of general relativity, there is no simple notion of keeping constant a particular number associated with a physical system's energy.**

A more complicated notion is called "conservation of stress-energy." Stress-energy is not a single number, but rather a collection of 16 numbers. This complicated series replaces the simpler Newtonian notion of "conserved energy." Conserving this new series of sums can violate the much more approximate Newtonian conservation laws. — **SIMON DEDEO,** UNIVERSITY OF CHICAGO

STAR FORMATION

Q: Why didn't Jupiter become a star? — **GERALD REED,** LEAVENWORTH, KANSAS

A: Stars form deep within dense clouds of cold molecular gas and dust. The clouds become gravitationally unstable and collapse rapidly to smaller sizes and higher densities. Rotation causes the infalling gas to form a flattened disk around each growing protostar. Most of the gas and dust in this protostellar disk are able to flow onto the central protostar, adding to the potential star's mass.

This process slows after about 100,000 years, after most of the pre-collapse cloud has fallen onto the system. The disk is thereafter termed a protoplanetary disk. Planets coalesce out of these disks well after their host stars. **Because a protoplanetary disk's mass tends to be no more than about 10 percent of its central star's mass, it is difficult for a growing planet to become as massive as a star,** i.e., to exceed about 75 Jupiter-masses.

Once a gas-giant planet similar to Jupiter forms, it is massive enough to create a gap in the disk. The gap then slows the rate at which the gas-giant planet accretes more gas. Thereafter, the planet grows more slowly, while other planets or the central star accrete the remaining disk gas.

However, if a Jupiter-mass object forms at the same time its host star forms, it can

NASA/JPL/SPACE SCIENCE INSTITUTE

JUPITER REVEALS ITS STRIKING BANDS and Great Red Spot in this cylindrical map. The Cassini imaging team took the 36 images for this map using Cassini's narrow-angle camera during the spacecraft's December 11 and 12, 2000, flybys.

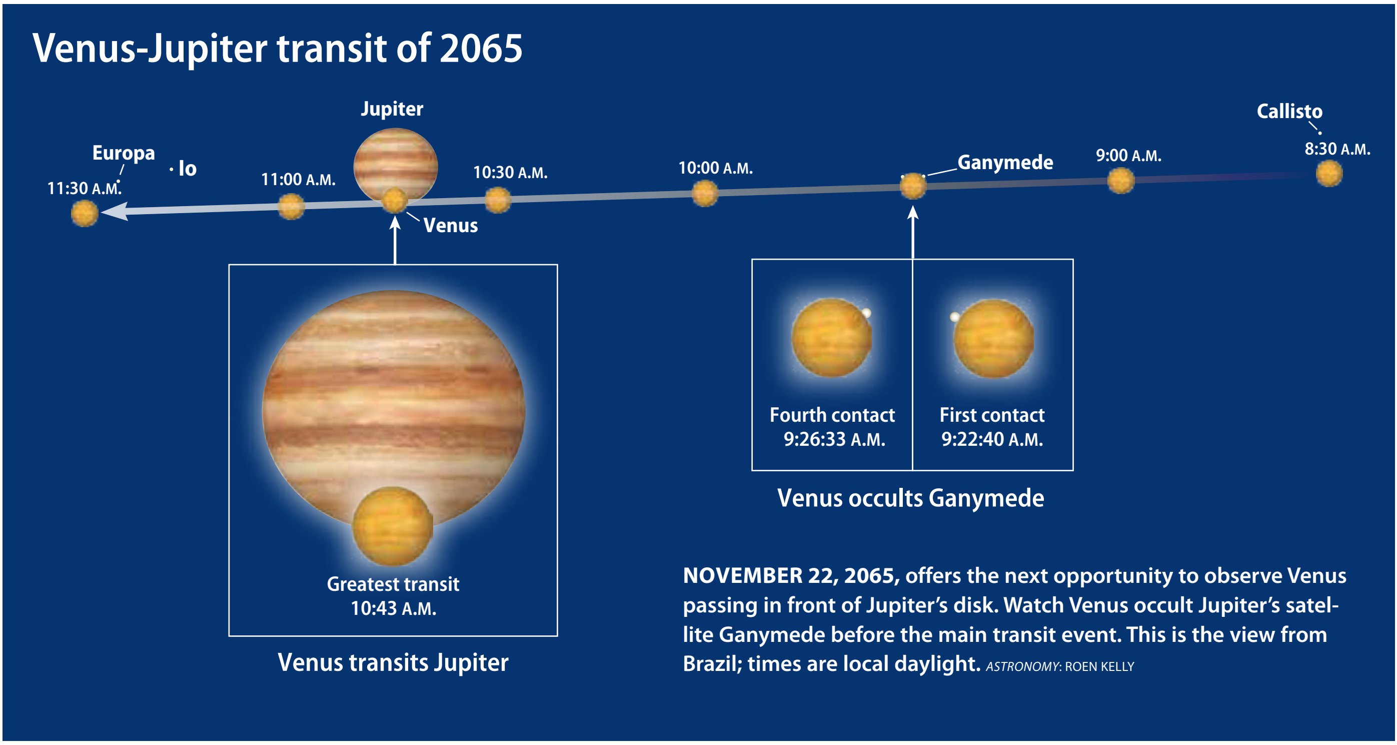
IN THE KNOW

OCCULTATION
A smaller object disappears behind a larger foreground object.

PROTOPLANETARY DISK
A rotating disk of gas and dust around an infant star.

THEORY OF GENERAL RELATIVITY
Matter causes space to curve. Gravity is a manifestation of space-time curvature.

TRANSIT
A smaller body crosses the disk of larger background object.



Venus-Jupiter transit of 2065

NOVEMBER 22, 2065, offers the next opportunity to observe Venus passing in front of Jupiter's disk. Watch Venus occult Jupiter's satellite Ganymede before the main transit event. This is the view from Brazil; times are local daylight. *ASTRONOMY:* ROEN KELLY

compete with its protostar for the infalling matter from the pre-collapse cloud and may gain enough mass to become a star itself: This is how binary stars form. — **ALAN BOSS,** CARNEGIE INSTITUTION OF WASHINGTON

PLANET OCCULTATIONS

Q: Do the planets ever transit or occult each other? — **JOE PAZOUREK,** MIDDLE RIVER, MARYLAND

A: **Yes, but these events are rare.** Each planet's orbit is inclined to Earth's by varying amounts, so there's only a small chance two planets and Earth will line up just right. In fact, there hasn't been a transit (a smaller body crossing the disk of a larger background object) or occultation (a smaller object disappearing behind a larger foreground body) between two planets since Jupiter occulted Venus January 3, 1818. The next transit isn't until 2065, when Venus transits Jupiter November 22.

English monk Gervase of Canterbury provided one of the first Western descriptions of a mutual planetary transit. On September 12, 1170, Mars crossed the disk of Jupiter. The event ended moments after Gervase saw the planets rise. He recorded that "Two planets were seen in conjunction to such a degree that it appeared as though they had been one and the same star; but immediately they were separated from each other." Chinese observers also witnessed the event, calling it an occultation.

On the evening of May 28, 1737, English amateur astronomer John Bevis used a telescope at Greenwich Observatory to watch Venus approach Mercury. The planets were low on the horizon, and clouds often obscured his view, but Bevis briefly glimpsed Venus before it covered Mercury and once again after the occultation began. Bevis' report is the only detailed account of such an event.

The next opportunity arrives November 22, 2065, around 12h43m UT (10:43 A.M. in Brazil), when Venus transits Jupiter, but the pair lies only 8° west of the Sun. This means observing the event will require both optical aid and solar protection. Orbiting telescopes probably will give us the best views.

Venus, at the farthest point in its orbit, will be at its smallest (9.9") and faintest (–3.9). Jupiter, appearing nearly 3 times larger, will provide a 31"-wide, magnitude –1.7 backdrop. At their closest, the two planets will gleam as one magnitude –4.0 object. And there's even a bonus: Before transiting Jupiter, Venus actually occults the large jovian moon Ganymede. — **FRANCIS REDDY,** ASSOCIATE EDITOR

FUTURE PLANETARY TRANSIT AND OCCULTATION EVENTS

Date	Event
Nov. 22, 2065	Venus transits Jupiter
July 15, 2067	Mercury occults Neptune
Aug. 11, 2079	Mercury occults Mars
Oct. 27, 2088	Mercury transits Jupiter
April 7, 2094	Mercury transits Jupiter
Aug. 21, 2104	Venus occults Neptune
Sept. 14, 2123	Venus transits Jupiter
July 29, 2126	Mercury occults Mars
Dec. 3, 2133	Venus occults Mercury

Send your questions to: askastro@astronomy.com; or write to: Ask Astro, P. O. Box 1612, Waukesha, WI 53187. Be sure to tell us your full name and where you live. Unfortunately, we cannot answer all questions submitted.

NEED ASTRO EQUIPMENT?

ASTRONOMICAL TELESCOPES
ASTRONOMICAL BINOCULARS
TRIPODS & MOUNTS
EYEPIECES & DIAGONALS
ASTRONOMICAL FILTERS
ASTROPHOTOGRAPHIC EQUIPMENT
BOOKS & STAR CHARTS
COMPUTER SOFTWARE
SOLAR OBSERVATION
OPTICAL CLEANING & CARE

SAVE UP TO 40%
EXPERT HELP

MEADE
CELESTRON
PARKS
LUMICON
TeleVue Visionary
JMI JIMS MOBILE INC
WILLIAM OPTICS
Thousand Oaks Optical
KONUS
CORONADO
Vixen
Kowa
Starry Night
SBIG
ZEISS
Nikon
Canon
FUJINON
LOSMANDY
KENDRICK ASTRO INSTRUMENTS
STELLARVUE

For All Major Brands at Discount Prices, Visit **SCOPECITY.COM**,
Any Scope City Center or Call Us Directly 800.235.3344

- SIMI VALLEY, CA 805.522.6646
- SHERMAN OAKS, CA 818.789.5805
- COSTA MESA, CA 714.957.6900
- SAN DIEGO, CA 858.277.6686
- SAN FRANCISCO, CA 415.421.8800
- LAS VEGAS, NV 702.947.2673

Scope City
The Largest And Most Complete Optical Centers In The World

FREE Eyepiece from Shutan

with purchase of almost every Meade or Celestron telescope! Call for details

Meade Accy's

AC adapter #541 ..	$50
AC adapter #547 ..	70
Alum case ETX90 .	115
Alum case ETX105	150
Alum case ETX125	150
Autostar wireless ...	199
Filter set-1, 2, or 3	50
Focuser 1244/1247	120
Flip-mirror #644	150
Flip-mirror #647	250
Focal reducer f:6.3	130
Focal reducer f:3.3	150
Laser collimator	70
Nebula 908 B	80
Nebula 908 N	90
Nebula 908 O-III ...	100
Off-axis guider	80
T-adapter #64	35
T-adapt: SCT	27
Vibration pads	50
Vari pol 905	50

Call for other items!

Celestron Sky Scout

In Stock

Pneumatic Chair

Padded seat adjusts 20-30" high
$119

High Quality Planetary Filters

just $99

Complete set of 12
Made in Japan- 1.25"

William Optics
ZenithStar 66SD APO

$369

FREE
99% Diagonal

Extremely-portable APO scope. Crayford 2-speed focuser. Ideal for fast set-up and travel. ***Includes fitted aluminum carrying case!***

Canon Binoculars
Image-Stabilized
Rebates to $100
3-Year USA Warranty!

Now Celebrating our 88th Year!

Lithium-Powered
Green Lasers last longer in cold weather!

just $109 *We also have laser finder brackets for telescopes!*

Armored Accessory Cases

Foam interior plus a divider set!

9 x 12 x 3"	$50
9 x 15 x 5"	60
12 x 17 x 5"	60

Many items = Free S/H

Coronado PST Solar Telescope!

$499

See solar prominences with the naked eye!

FREE SHIPPING!

We carry dew-prevention equipment

JMI Rolling Scope Cases

from $339

Glass Solar Filters

Yellow-orange image,
Lifetime Warranty!

ETX90/105	$80
ETX125/Next-5......	100
5" full aperture	100
6" full aperture	110
8" full aperture	139
9.25" full aperture .	149
10" full aperture	159
11" full aperture	179
12" full aperture	189
14" full aperture	199

Call for other sizes

LUMICON

The very best light pollution filters!

Meade DSI CCD Imager $299
Complete USB-connect **color** camera with planetarium software and image stacking software. Use with **any brand** 1.25" telescope!

MEADE

Series 5000
82° UltraWide

4.7 or 6.7mm	$199
8.8 or 14mm	199
18mm	279
24mm (2")	399

Series 5000
68° SuperWide

16mm	179
20mm	199
24mm	249
28mm (2")	279

Series 5000
60° Plossl

5.5 or 9mm	89
14 or 20mm	89
32mm (2")	149
40mm (2")	199

Series 5000
Barlows/Diagonals

1.25" 2x or 3x ..	159
1.25" 5x	159
2-inch 2x	229

Call for other Meade

TeleVue Visionary

Nagler-82°

2.5, 3.5, 5, 7, 9, 11, or 13mm........ea.	$290
12mm	365
16mm	330
17mm (2")	395
20mm (2")	450
22mm (2")	480
26mm (2")	600
31mm (2")	640

Radian-60°
3, 4, 5, 6, 8, 10, 12, 14, or 18 ....ea. **$250**

Panoptic-68°

15mm	**215**	19mm	**245**
22mm	**285**	24mm	**310**
27mm	**345**	35mm	**380**

Barlows/Diagonals

1.25" 2x or 3x	110
2.5x or 5x.............	195
2-inch 2x	205
2-inch P-Mate	295
2-inch 4x	310
2" Everbrite	275
1.25 Everbrite	190

Call for other Televue

<<FREE CATALOG<< Order our 84-Page catalog toll-free or online. Shutan is family owned and operated since 1918. Prices subject to change. Call for free eyepiece details and offer end date. ©10/06

SHUTAN *camera & video*

We welcome bids & PO's from Schools!
more items at: www.shutan.com
Toll-Free 800-621-2248 • IL 847-367-4600
Retail showroom located in Vernon Hills, Illinois

Shower Them with Gifts

At Skies Unlimited we have the expertise, selection and competitive pricing to make this Holiday Season the best ever.

HAPPY HOLIDAYS
from
Skies UNLIMITED

MEADE
ORION TELESCOPES & BINOCULARS
CORONADO
CELESTRON
TeleVue Visionary
Vixen

(888) 947-2673

SHOWROOM HOURS
10 AM to 5 PM - MONDAY THRU WEDNESDAY
10 AM TO 7 PM - THURSDAY & FRIDAY
10 AM TO 5 PM - SATURDAY
12 PM TO 5 PM - SUNDAY

CONVENIENTLY LOCATED NEAR MAJOR NORTHEAST METRO AREAS

NEW LOCATION - Suburbia Shopping Center (Route 100-Chester County), Pottstown, PA 19465
www.skiesunlimited.net

Web Site Directory

Check out these businesses... They're only a click away!

ASTROZAP
astrozap@yahoo.com
www.astrozap.com
Your #1 source of dew prevention shields on the planet.
Hundreds in stock! Dew it in style!

EFSTONSCIENCE
sales@telescopes.ca
www.telescopes.ca
Science & Astronomy SuperStore since 1970.
Canada's best prices selection and staff.

FOCUS CAMERA & VIDEO
www.FocusCamera.biz
Thousands of telescopes, eyepieces, accessories, binoculars, digital photography, & consumer electronics.
1-877-883-5937

KHAN SCOPE CENTRE
info@khanscope.com
www.khanscope.com
Serving Canada & U.S. for over 19 years
Toll Free: 1-800-580-7160
Telescopes & Accessories at Discount Prices

STARIZONA
Let's Talk Stars
www.letstalkstars.com
With your Hosts David and Wendee Levy
Astronomy talk radio

For advertising information call Ken Kozerski at:
1-888-558-1544
ext. 636

TECHNIQUES

You can turn astronomical data into gorgeous images with the authors' *Photoshop* plug-in. /// **BY ROBERT L. HURT AND LARS LINDBERG CHRISTENSEN**

Make Hubble shots your own dazzling photos

THE CONE NEBULA **(NGC 2264) is a knotty, nebulous mass of gas, dust, and infant stars in this Spitzer Space Telescope infrared image processed with *FITS Liberator*. Newborn stars, which appear red, are embedded within a section of the Christmas Tree Cluster (lower middle center).** NASA/JPL-CALTECH/ P. S. TEIXEIRA (CENTER FOR ASTROPHYSICS)

Astronomy is largely a science of pictures. Modern astronomical photos are mostly digital, which allows for precise analysis. Yet, in digital form, these images are far removed from the breathtaking images produced using conventional film photography. Amateurs can also find some file formats challenging to work with.

The Flexible Image Transport System, or FITS — a universal file format for storing astronomical data, including images — is such a file format. First developed in 1982, the FITS format manages a wide variety of incompatible data formats. Unfortunately, the FITS format's great flexibility also makes working with FITS files difficult for non-scientists.

Images stored in FITS format generally can be extracted only by using professional image-analysis software. However, recently, the Adobe software company has introduced a free plug-in for the popular image-processing software *Photoshop* designed to make FITS files easier to manipulate. *Photoshop* is a powerful yet easy-to-use tool for laypersons, educators, and artists. You can find the free plug-in at www.spacetelescope.org/projects/fits_liberator.

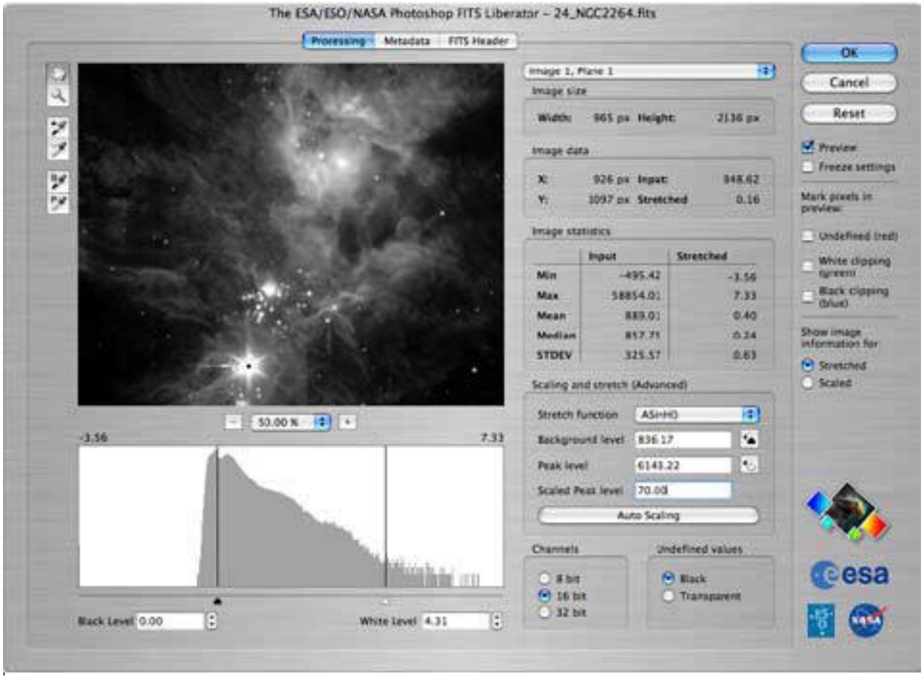


Image 1, Plane 1

Image size

Width: 965 px Height: 2136 px

Image data

X: 926 px Input: 948.62
Y: 1097 px Stretched 0.16

Image statistics

	Input	Stretched
Min	-495.42	-3.56
Max	58854.01	7.33
Mean	889.01	0.40
Median	857.71	0.34
STDEV	325.57	0.63

Scaling and stretch (Advanced)

Stretch function: ASinH0
Background level: 836.17
Peak level: 6141.22
Scaled Peak level: 70.00

Channels: ○ 8 bit ● 16 bit ○ 32 bit

Undefined values: ● Black ○ Transparent

☑ Preview
☐ Freeze settings

Mark pixels in preview:
☐ Undefined (red)
☐ White clipping (green)
☐ Black clipping (blue)

Show image information for: ● Stretched ○ Scaled

50.00 %

Black Level 0.00

White Level 4.31

FITS LIBERATOR'S **interface screen displays your image and several processing settings from which to choose. The main sections of the *FITS Liberator* user interface include a zoomable preview window, a dynamically updating histogram, basic image statistics, image-stretching options, and preferences.** NASA/JPL-CALTECH/ P. S. TEIXEIRA (CENTER FOR ASTROPHYSICS)

FITS Liberator software is a new tool to help bridge the gap between analytical data and appealing images.

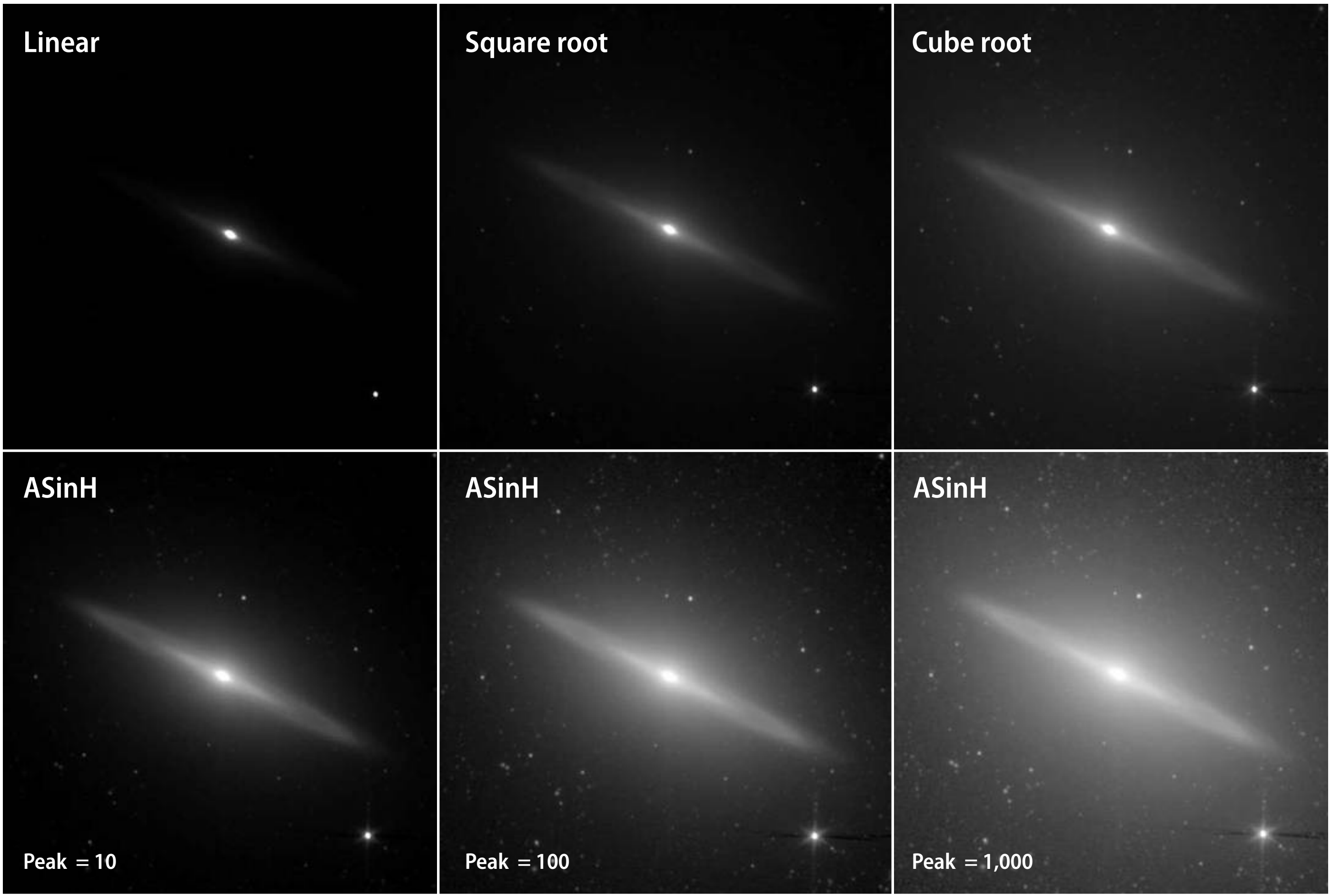
Public archives exist online with data gathered by the Hubble, Spitzer, and Chandra space telescopes, as well as from a multitude of ground-based observatories. *FITS Liberator* opens these datasets of color images to anyone interested in exploring the beauty of the universe.

Finding the picture within

The whimsically named *FITS Liberator* frees the "picture" from the shackles of the FITS format. The software's origins date back to the Space Telescope Science Institute's 2003 Imaging in Astronomy Workshop.

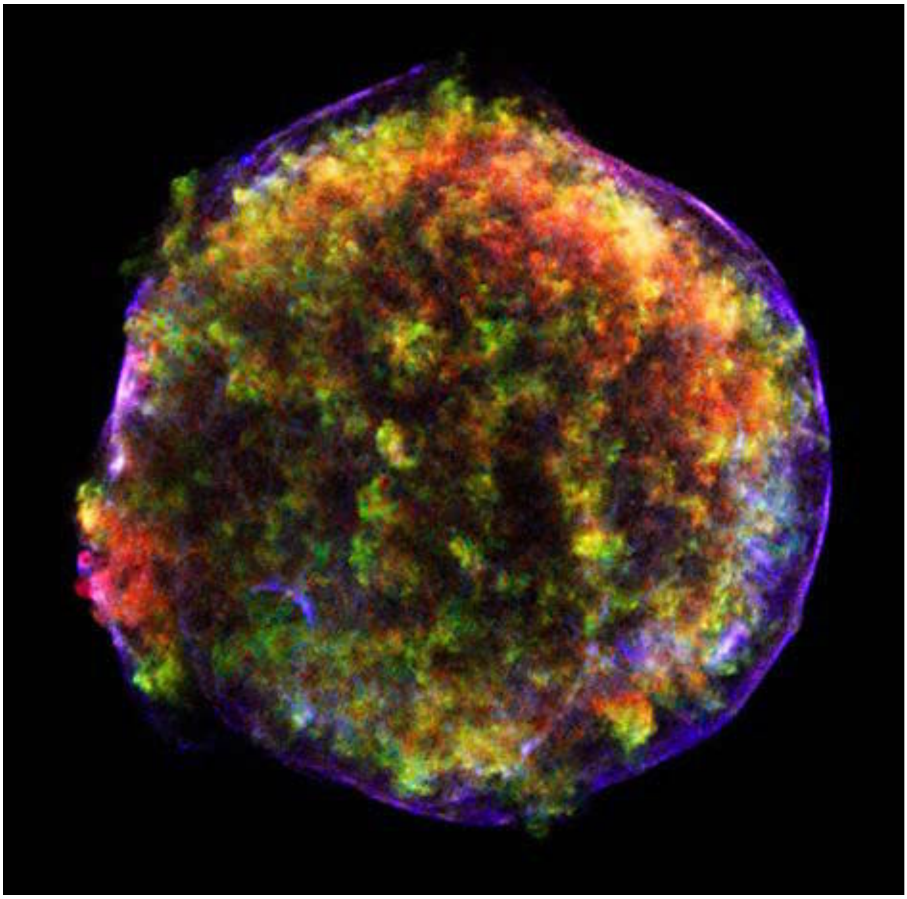
While most attendees used *Photoshop* for image development, none had a quick and efficient method of importing FITS

Robert L. Hurt *is a scientist at the Spitzer Science Center in Pasadena, California.* **Lars Lindberg Christensen** *is a public information officer for the European Space Agency and the International Astronomical Union.*



STRETCH FUNCTIONS result in different overall effects in this Spitzer Space Telescope infrared image of the Sombrero Galaxy (M104). The "linear" image is a direct mapping of brightness to the screen, losing all of the outer details.

Different mathematical functions may bring up different degrees of the fainter dust ring and halo of stars. Six stretch functions — three root functions (linear, square root, and cube root), and three inverse hyperbolic sine functions (ASinH) with different scaling factors stretch the Sombrero in a variety of ways. Which stretch function you choose in *FITS Liberator* can help display data with large dynamic range by suppressing an image's brighter areas and enhancing its fainter areas. NASA/JPL-CALTECH/R. HURT



TYCHO'S SUPERNOVA REMNANT (SN 1572) appears to boil forth from space in this Chandra X-ray Observatory image, produced using *FITS Liberator*. The shock front (blue) from this supernova, which blew up in 1572, barely outpaces the stellar debris (green/red) ejected from this tremendous explosion. NASA/CXC/RUTGERS/J. WARREN & J. HUGHES ET AL.

data until the release of *FITS Liberator* Version 1.0 in July 2004. Version 2.1, released in September 2006, currently boasts more than 50,000 users.

How the plug-in works

FITS Liberator streamlines the astroimaging process and allows non-technical artists to explore the beauty within scientific data. The basic interface includes a zoomable preview window, a histogram, basic image statistics, image-stretching options, and other settings.

After the program is installed, you can open a FITS file just like any other image *Photoshop* handles. The resulting grayscale image can be saved in any format (such as JPEG, TIF, or PNG).

After saving the image file, you can use *Photoshop* to create an attractive color composition from the grayscale image. Images can be tinted in a variety of ways or recolored using a gradient map.

Multiple exposures of an object also can be combined into a full-color image: Assign grayscale images taken through different "filters" (e.g. at different wavelengths) to the red, green, and blue color channels. *FITS Liberator*'s web site, www.spacetelescope.org/projects/fits_liberator, provides instructions and tools to assist in this process.

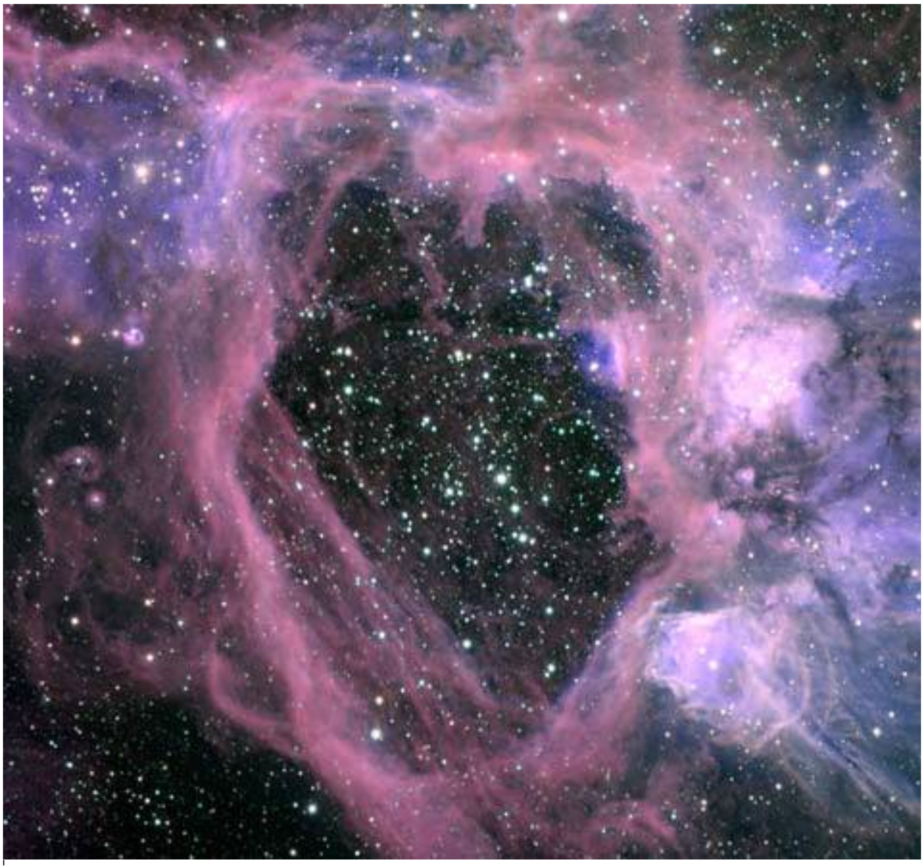
The dynamics of range

Dynamic range is the brightness ratio between an image's lightest and darkest regions. When bright areas are properly exposed, detail in darker areas is lost. Increasing exposure time recovers detail from dark areas, but bright areas are overexposed. FITS images often have large dynamic ranges. For example, structure in a galaxy's outer regions can be tens of thousands of times fainter than at its bright center.

A key feature of *FITS Liberator* is its ability to compress the dynamic range in such data sets. FITS data are mathematically rescaled using a stretch function then displayed on the screen.

What isn't a stretch is your ability to create a wide range of beautiful, dynamic, and balanced astroimages as captivating as those released by the Hubble team with *FITS Liberator*. A

ONLINE EXTRA Learn to manage your metadata at www.astronomy.com.



GEMINI OBSERVATORY/T. RECTOR (UAA)

THE N44 SUPERBUBBLE COMPLEX in the Large Magellanic Cloud contains a giant central bubble spanning 250 light-years. Outflowing winds from a massive star cluster have swept away gas and dust. The image, made using *FITS Liberator*, shows a 9.8' by 5.5' field of view.

THE ART OF THE SCIENCE: A HISTORY OF ASTROPHOTOGRAPHY

The first astronomers to turn telescopes skyward were also artists out of necessity. Only through their sketches could they record and share with others what they saw. Such records, while beautiful, are subject to the observer's biases. Remember those martian canals "seen" by Percival Lowell in the 1890s?

Photography allowed astronomy to evolve into a more objective science. Astronomers became proficient photographers: choosing the appropriate film, calculating appropriate exposure times, and framing their shots. Their research data could just as easily be framed and displayed in an art gallery.

The earliest astrophotography was black-and-white. While the advent of color emulsions allowed the full natural colors of the universe to be seen, they reduced the film's sensitivity, which limited its utility in astrophotography.

In the 1970s, a new approach popularized by the work of Australian astrophotographer David Malin brought color to astroimages in an innovative way: by exposing black-and-white film through red, green, and blue filters, then exposing color film using three negatives and matching filters.

Throughout the 1980s, long before the first consumer digital camera hit the market, astronomers pioneered the emerging field of digital imaging. New detectors called charge-coupled devices (CCDs) heralded an era of analytical accuracy, actually counting photons of light directly.

However, converting digital astronomical datasets back into aesthetically pleasing images requires its own kind of artistry. Astroimagers must consider exposure time, contrast, and image composition in order to render a CCD's electronic data into a range of dark to light values that can be viewed on a computer or printed in a book.

In the 1990s, astronomers like Zoltan Levay of the Space Telescope Institute helped pioneer astrophotography techniques that led to *FITS Liberator*'s development in the early 2000s. — *R. H. and L. L. C.*

Tele Vue®
"is"
Telescopes

Rosette Nebula imaged with Tele Vue-60is by James Burnell, co-author of The Handbook of Astronomical Imaging Processing .

Tele Vue-NP127is
4-element, Nagler-Petzval APO
5", f/5.2, 660mm
2.4", 6:1 focuser

Tele Vue-NP101is
4-element, Nagler-Petzval APO
4", f/5.4, 540mm
2.4", 6:1 focuser

Tele Vue-NP102iis
2-element APO
4", f/8.6, 880mm
2.4", 6:1 focuser

Tele Vue-60is
2-element APO
2.4", f/6, 360mm
2.0", 6:1 focuser

Imaging systems for the discerning astrophotographer, apochromatic instruments for the discerning observer.

More "is" images at TeleVue.com!

Adorama	Anacortes Telescope	Astronomics	Oceanside Photo	Telescopes.com	Woodland Hills Telescopes
800.223.2500	800.850.2001	800.422.7876	800.483.6287	800.303.5873	888.427.8766

TeleVue®
Visionary

Tele Vue Optics, Inc., 32 Elkay Drive, Chester, New York 10918 845.469.4551 www.TeleVue.com

Study the Universe Via the Internet

→ Doctor of Astronomy/PhD
→ Master of Astronomy
→ Master of Astronomy Education
→ Certificate and Diploma

www.jcu.edu.au/astronomy
Contact: astronomy@jcu.edu.au

Centre for Astronomy

JCU James Cook University

Astronomy magazine is pleased to announce a new partnership in astronomy tours and travel — **MWT Associates, Inc.**
Together we invite you to join the search for Northern Lights in Iceland personally escorted by *Astronomy* magazine's copy editor Laura Baird.

March 16-22, 2007 • Price: $2,095 per person
(Double occupancy if deposited by October 25, 2006 — $310 Single Supplement.)

Tour includes:

- Round-trip airfare from selected USA gateways
- Airport hotel transfers
- Five (5) nights accommodations at the Four Star, Nordica Hotel
- Scandinavian buffet breakfasts daily, 1 salmon lunch and 3 special dinners
- Fully guided by experienced English-speaking driver and guide
- Reykjavik City tour including Hallgrimskirkja, Hofidi House and the Pearl
- Blue Lagoon Tour bathing in a mineral-rich pool, geothermal-heated water
- Full-day tour: Thingvellir landmark, Gullfoss Falls, the Great Geyser
- Astronomical commentary and aurora hunt
- South Shore Tour to view Mt. Hekla and Icelandic Folk Museum

For more information contact:
MWT Associates, Inc. • www.melitatrips.com
1-877-707-7827 • CST: 2040611040 *Inspiring the Stargazer in You*
TUR-ADH-06X1175RH

Astronomy magazine

HyperStar
The only thing faster is light!
f/1.8

10 Minute Image mosaic by Dail Terry
Using a HyperStar on GPS11 w/Starlight SXV-H9C
Shot Alt/Az, No Guiding, 2 X 10@30 second exposure
www.starizona.com
520-292-5010

INDEX of ADVERTISERS

Abbeville Telescope Company ... 96
Adorama ... 23, 74
Ash Manufacturing ... 100
Astro-Physics ... 98
Astronomics ... 32-33
Astronomy Delight ... 97
Astronomy Technologies ... 96
Astronomy Binders ... 75
Astronomy Calendars ... 100
Astronomy magazine ... 94, 97, 99
Astronomy magazine Iceland Tour ... 89
Astronomy Sweepstakes ... 10-11
Astronomy.com ... 95, 99
Astrozap ... 83
Beam of Light Technologies ... 98
Beta Electronics ... 99
Big Bang Astronomy Shop ... 100
Binoculars.com ... 99
Bob's Knobs ... 99
Canon USA Inc ... 26, 27
Celestron ... 22, 93, 106
Cercis Astro ... 99
Coronado Technology Group ... 7
DBAAstronomy ... 97
Denkmeier Optical ... 96
Efstonscience, Inc ... 83, 98
Focus Camera ... 83, 97
Glatter Howard ... 98
James Cook University ... 89
Jim's Mobile, Inc ... 63
Khan Scope Centre ... 83
Kitt Peak National Observatory ... 63
Lake Michigan Tile ... 98
Let's Talk Stars ... 89
Luckyduck.com ... 97
Lumicon ... 29
Mag One Instruments ... 99
Max Factory ... 98
Meade Instruments Corporation ... 2, 3, 13, 14, 15
Moonlite Telescope Accessories ... 96
Newport Glass Works ... 96
Obsession Telescopes ... 98
Oceanside Photo & Telescope ... 75
Orion Telescopes & Binoculars ... 62, 105
Owl Services ... 96
Parks Optical ... 21
Rainbow Symphony ... 96
Ritz Camera Superstores ... 100
Rivers Camera Shop ... 74, 100
Scope Buggy ... 99
Scope City ... 82
Scope Merchant, The ... 99
ScopeStuff ... 99
SCS Astro ... 99
Shutan Camera & Video ... 82
Sirius Observatories ... 100
Skies Unlimited LLC ... 83
Smartastronomy.com ... 96
Solarscope ... 99
Southeastern Camera & Telescope ... 98
Stargazers Inn ... 99
Starmaster Portable Telescope ... 99
Starizona ... 83
Stellarvue ... 97
Surplus Shed ... 99
Swinburne University Of Technology ... 74
Technical Innovations ... 74
Tele Vue Optics, Inc ... 17, 88
The Teaching Company ... 19
University of Arizona ... 63
Vixen Optics ... 31
Wicked Lasers ... 96
William Optics, Co. ... 29
Woodland Hills Photo Images ... 95
www.bigbinoculars.com ... 99
Zero Products ... 97

EQUIPMENT REVIEW

Don't let this scope's compact size fool you — it's a high-quality workhorse. /// **BY PHIL HARRINGTON**

Celestron's Onyx 80EDF

Each decade brings new telescopes or mounts, usually with one particular design dominating the market. In the 1970s, everyone wanted to own a Schmidt-Cassegrain telescope. In the 1980s, it was large, Dobsonian-mounted reflectors. Today's trendsetting design is small "grab-and-go" refractors characterized by apertures of 4 inches (102 millimeters) or less and focal ratios in the f/5 to f/7 range.

What makes this niche so hot is more and more mid-range models offer a compromise between price and quality. The latest entry into this burgeoning market is Celestron's Onyx 80EDF.

Onyx specifications

The Onyx 80EDF is a compact 3.1-inch (80mm) f/6.25 telescope that comes in a padded aluminum case. The glossy black aluminum tube, with its orange inlaid logos and accent ring around the base of the sliding dew cap, has a rich luster that belies this scope's moderate price.

Other desirable features include a sliding dew shield, rotatable Crayford-style focuser, dovetail mounting block, lens caps, and a side-mounted aiming tube. Eyepieces and a star diagonal are sold separately. Celestron covers the Onyx 80EDF with a 2-year factory warranty.

Small refractors have been around for years, but a huge gap in price and quality has existed among models. Some cost less than $200, but, with lenses having only simple color correction, they have distracting purple halos around bright objects. Called residual chromatic aberration, such a halo results from different wavelengths of light coming to focus at various distances from the objective (front lens). Manufacturers eliminate this problem in expensive apochromatic refractors. Despite its lower price, the Onyx 80EDF rivals some aspects of the high-end models.

To reduce chromatic aberration, the Onyx's objective combines a lens made of Fluoro-crown glass (technically specified as O'Hara FPL-53) with another of high-density crown glass. FPL-53 is the most advanced extra-low dispersion glass available. Lens designers use it to shrink focal ratio while maintaining color correction.

To enhance image contrast, Celestron also vacuum-coats the objective's elements with Celestron's StarBright XLT coatings. The coatings appear uniformly dark-green in daylight.

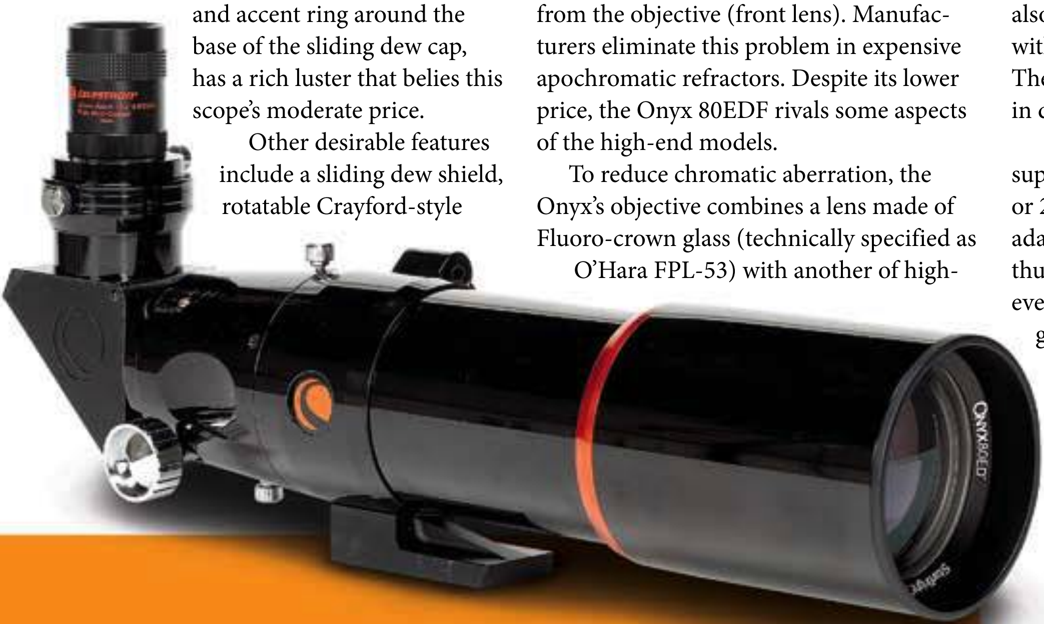
The single-speed Crayford-style focuser supplied with the Onyx accepts either 1¼" or 2" eyepieces, thanks to the included adapter. Turning the focuser's locking thumbscrew presses a compression ring evenly against the eyepiece barrel. That's a good way to keep eyepiece barrels from being marred, as they would be if a thumbscrew pressed against them directly. High-end telescopes have used this technique for years, but it's nice to see it filter down to more moderately priced instruments.

The Onyx 80EDF's focuser also can be rotated 360° by loosening a second

/// SPECIFICATIONS

CELESTRON ONYX 80EDF

Type: Two-element refractor
Aperture: 3.1" (80mm)
Focal ratio: 6.25
Focal length: 500mm
Length: 16" (406mm)
Weight: 6.1 pounds (2.77 kg)
Also: Celestron StarBright XLT coatings, 2" Crayford-style rotatable focuser, built-on metal sight scope, extendable dew shield, integrated dovetail, foam-lined aluminum carrying case.
Street price: $649



THE ONYX 80EDF packs a lot of optical punch in a small package. Measuring only 16" (406mm) long and weighing 6.1 pounds (2.77 kg), the 80EDF features Celestron's StarBright XLT coatings on all optical surfaces. ALL PHOTOS: *ASTRONOMY*: JAMES FORBES

Phil Harrington *is the author of the telescope-review book* Star Ware *(John Wiley & Sons). The 4th edition will be released in March 2007.*

thumbscrew. Rotating the focuser does not cause the telescope's optics to lose their collimation (alignment).

With the dew shield collapsed, the Onyx measures only 16 inches (406mm) long. Its 6-pound (2.7 kilograms) weight is light enough for any reasonably sturdy camera tripod. A mounting block affixed permanently to the telescope tube includes a ¼"-20 threaded hole for camera-tripod mounting. Celestron cleverly designed the mounting block's profile to match the dovetail plate used on many of today's popular equatorial mounts. The plate attaches without additional rings or adapters.

I used the Onyx on my own Celestron CG-5GT go-to mount for this review. Because the CG-5GT is designed to support far heavier telescopes than the Onyx, the combination made for one of the steadiest platforms I've seen. Any vibrations settled out in less than a second.

Throughout these tests, I used a Celestron 2" StarBright XLT mirror star diagonal, which is sold separately. Retailing for around $140, the StarBright diagonal is well matched to the Onyx. Inside, the optically flat mirror is coated with 96-percent enhanced aluminizing to produce bright, sharp images. The diagonal's mechanical quality also is exceptional, with a tapered barrel, a compression-style eyepiece ring, and a glossy black finish.

The Onyx does not include a finder scope or single-power finder. Instead, it comes with a small, hollow sight tube permanently mounted to the telescope tube.

The sight tube rides only ⅝" (1.6 centimeters) off the telescope, which made access difficult at times, depending on where I pointed the scope. The sight would have been more useful on the focuser's rotatable housing, so it could be spun around as needed. Its black color makes it difficult to find at night, even with light pollution. I found it much easier to sight along the telescope's tube and then use a low-power eyepiece to center the target in the field of view.

Testing under the stars

Aiming toward 2nd-magnitude Kochab (Beta [β] Ursae Majoris), I began star-testing the Onyx using a 5mm eyepiece, which yielded a magnification of 100x. Turning the focuser in and out, the star expanded smoothly in both directions. The out-of-focus rings appeared concentric, confirming that the Onyx's optical system was properly collimated.

Repeating the process several times revealed the Onyx's objective lens to be well-figured but with a hint of spherical aberration. I also noted a miniscule amount of astigmatism in the system, as evidenced by a slight ellipticity to the rings when passing from one side of focus to the other. Both of these minor flaws could have been caused by a too-tight lens cell warping the objective. Under the stars, however, neither flaw diminished the view of any of my chosen targets.

Because of its short focal ratio, most observers would claim the Onyx's strong suit is not as a planetary telescope. Still, I couldn't resist the lure of Jupiter hanging high in the southwest. A 10mm eyepiece (50x) easily showed the jovian atmosphere's main belts, while the 5mm (100x) resolved the Great Red Spot's "hollow" as well as a pair of satellite shadows transiting the planet's disk. Jupiter appeared sharp and clear, with a slight purplish halo of false color encircling its limb. I also saw purple fringing around the Moon's limb.

Swinging over to everyone's favorite colorful double star, Albireo (Beta [β] Cygni), I found both the primary's yellowish color and its companion's bluish hue coming through vividly. I next made my way to the Double Double (Epsilon [ε] Lyrae) quadruple star system in neighboring Lyra. With the 5mm eyepiece still in place, the Onyx cleanly resolved all four components.

Image quality held up well even as I inserted a 2.5x Barlow lens into the system, raising the magnification to 250x. That combination also split the challenging double stars Alrischa (Alpha [α] Piscium) as well as Delta (δ) Cygni. Not bad for a 3.1-inch scope, especially because splitting the latter star usually is considered a good test for a 4-inch aperture.

I switched back and forth between the 5mm and 10mm eyepieces when I examined the Hercules Cluster (M13) and the Ring Nebula (M57). M13 appeared at the Onyx 80EDF's resolution limit, while the scope easily showed M57's characteristic smoke-ring shape at 100x.

This telescope's real strength lies in its superb low-power, rich-field views. When I popped a 22mm wide-field eyepiece into the focuser, the Onyx created a 23x, 3° field of view. When I scanned the Milky Way from Cygnus southward to Sagittarius, I was treated repeatedly to magnificent views of such diverse targets as the dark rifts in Cygnus, the open star clusters M6 and M7 in Scorpius, and the Lagoon (M8) and Trifid (M20) nebulae in Sagittarius.

Working with the Onyx 80EDF was an enjoyable experience. Is it a pure apochromat? No, given the purple fringing that I saw around the Moon and Jupiter. But given that it costs only a third of the price of a top-end refractor, Celestron's Onyx 80EDF represents a good value.

THE ONYX comes with a foam-lined aluminum case, excellent protection for transporting the scope. In addition to the telescope, the case can hold several eyepieces and a star diagonal.

A 2" CRAYFORD-STYLE rotatable focuser (with its own padded aluminum case) is part of the standard Onyx 80EDF package. For 1¼" eyepieces, just insert the included adapter.

DSLRSTAR CONTROLLER

Cercis Astro
Pennington, New Jersey

Price: $150
[t] 609.737.5120
[w] www.cercisastro.com

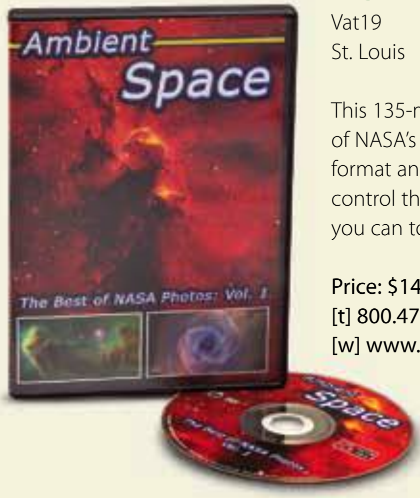
The DslrStar controller 400 is a digital single-lens-reflex camera accessory capable of storing 32 exposure sequences. The controller comes with a software CD, an AC adapter, and a USB cable.

AMBIENT SPACE DVD

Vat19
St. Louis

This 135-minute DVD highlights some of NASA's best photos. Its slide-show format and playlist technology let you control the order of each scene, and you can toggle captions on or off.

Price: $14.95
[t] 800.476.199
[w] www.vat19.com



SPECTRUM FILTER WHEEL

The Scope Merchant
Thousand Oaks, California

The Spectrum filter wheel fits into any 1¼" telescope eyepiece holder and includes a built-in 2x Barlow lens. This versatile filter wheel contains 12 colors and can be used for planetary, lunar, or terrestrial targets.

Price: $139.95
[t] 805.750.1609
[w] www.scopemerchant.com

SCOPEROLLER 8

ScopeRoller
Boise, Idaho

Roll your Losmandy GM-8 mount and telescope outside easily without disconnecting cables or removing the optical-tube assembly with ScopeRoller. Quick Release Toe Saver counterweight safety screws are also shown ($50).

Price: $50, plus shipping
[t] 208.938.5721
[w] www.scoperoller.com

TRUSS TUBE KIT

Astro Technologies Ltd.
Ottawa

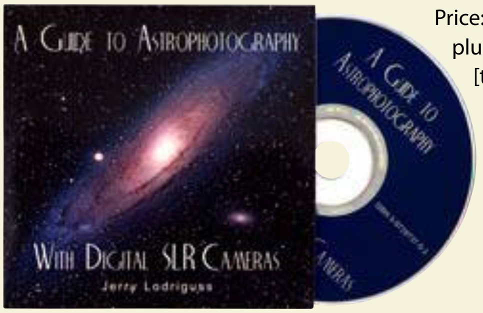
Price: $350 U.S. (1" kit), $600 U.S. (1½" kit), plus shipping
[t] 613.828.4756
[w] www.astrotechnologies.ca

The complete Truss Tube kit contains an upper-truss clamp assembly and lower-truss clamps to build your mirrors into a truss-tube scope. Components are anodized and available in blue, red, green, or polished aluminum.

A GUIDE TO ASTROPHOTOGRAPHY WITH DIGITAL SLR CAMERAS

Astropix LLC
Somerdale, New Jersey

Learn to create astroimages with digital SLR cameras using this book on CD-ROM. Astroimager Jerry Lodriguss guides you through the basics of astrophotography and digital processing.



Price: $39.95, plus shipping
[t] 856.770.8246
[w] www.astropix.com

Astronomy made simple.

Who says Astronomy has to be complicated? Let a NexStar SE help you find thousands of stars, planets galaxies and more at the touch of a button! The new NexStar SE family combines unprecedented ease of use with advanced features and incredible value. Buyer's remorse not included.

- Series features 4" Maksutov-Cassegrain, 5", 6" and 8" Schmidt-Cassegrain computerized telescopes
- Computerized hand control with nearly 40,000 object database and motorized altazimuth mount
- StarBright® XLT enhanced coatings for maximum light transmission and clarity
- SkyAlign™ allows you to align on any three bright objects, for a fast and easy alignment process
- Flash upgradeable hand control; update your telescope's operating software via the internet
- All Nexstar SE models are GPS compatible and come standard with an auxiliary port for use with additional accessories
- Internal battery compartment to prevent cord wrap during use
- Includes NexRemote™ telescope control software, for advanced control of your telescope via computer
- "THE SKY®" Planetarium software – with 10,000 object database, printable sky maps & enhanced images

CELESTRON
NexStar 6SE

NexStar 6^{SE}

SPECIAL REBATE OFFER! **$50 or $75**

Purchase a Nexstar SE between 11/1 - 12/31 and receive up to $75 cash rebate. Some restrictions apply, see your dealer or celestron.com for more details. Offer good for U.S. & Canada customers only.

NexStar® SE Series

[1] Align your NexStar SE telescope in minutes with our new SkyAlign technology. Just point the telescope at three bright stars and let the computer do the rest. You don't even need to know the names of the stars!

[2] Flash upgradeable hand control contains a database of nearly 40,000 celestial objects and advanced software features including SkyAlign, Identify Mode, User-definable Horizon Limits, and Precise GoTo.

[3] Designed for portability: with largest model weighing only 24 lbs, spend more time observing with these lightweight and easy to set-up telescopes.

[4] Exclusive Features of the 4^{SE} & 5^{SE}: tripod features built-in wedge which allows the them to be used for astrophotography! Includes a camera control feature that allows you to remotely take a series of timed exposures using your digital SLR camera.

1

2

3

4

NexStar 4^{SE} (4") shipping and handling $40.00	$599.00 before $50 Rebate
NexStar 5^{SE} (5") shipping and handling $45.00	$799.00 before $50 Rebate
NexStar 6^{SE} (6") shipping and handling $50.00	$999.00 before $75 Rebate
NexStar 8^{SE} (8") shipping and handling $60.00	$1399.00 before $75 Rebate

Suggested retail in U.S. Dollars. Pricing and shipping charges are suggested for products ordered and shipped in the U.S.A. only.

CELESTRON PREMIER SELECT DEALER

ASTRONOMICS	800.422.7876	www.astronomics.com
OCEANSIDE PHOTO AND TELESCOPE (OPT)	800.483.6287	www.optcorp.com
TELESCOPES.COM	888.988.9876	www.telescopes.com
OPTICS PLANET	800.504.5897	www.opticsplanet.com
SCOPE CITY	800.235.3344	www.scopecity.com
ADORAMA	800.223.2500	www.adorama.com
B&H PHOTO	800.947.9970	www.bhphotovideo.com

CELESTRON®
www.celestron.com/se

NEXT MONTH
in the February issue

CERN/CLAUDIA MARCELLONI

Astronomy

Is string theory wrong?
If it is, then dark matter, dark energy, and cosmic inflation are in big trouble.

New views of Mars
The first color images from the Mars Reconnaissance Orbiter's high-resolution camera show surface details smaller than the Mars Exploration Rovers.

What makes Mira tick?
Changes in this star's complex atmosphere power its pulsations.

Glimpse the naked galaxy
By observing in infrared wavelengths, astronomers peer through obscuring dust and reveal the Milky Way's spiral structure.

Winter's best star clusters
These 12 must-see stellar treats look their best in winter's crisp, clear air.

Save our night sky
Light pollution is a growing problem, but you can help curtail it.

Get more from your CCD
CCD cameras are revolutionizing astroimaging, enabling amateurs to capture more detail than ever before.

SUBSCRIBE TODAY!
1.800.533.6644
ORDER ONLINE AT
Astronomy.com

Looking ahead to 2007's star parties,
now is the time to make your plans — many events have attendance limits or require advance registration. Here are several popular gatherings from the first half of 2007. Next month, we'll look at events through the rest of the year.

JANUARY 17–21
Deep South Texas Stargaze
Escondido Ranch, McMullen County, Texas. For more information, visit www.kingsvilleastronomicalsociety.org.

JANUARY 27
Connacht Star Party
Westwoodhouse Hotel, Galway City, Ireland. For more information, visit www.galwayastronomyclub.ie.

FEBRUARY 11–17
Cedar Key Star Party
Chiefland Astronomical Village, Chiefland, Florida. For more information, visit upstateastro.org/stars/cedarkey.html.

FEBRUARY 12–18
Winter Star Party
Camp Wesumkee, West Summerland Key, Florida. *Astronomy* Managing Editor Dick McNally will attend. For more information, visit www.scas.org/wsp.htm.

FEBRUARY 14–18
Orange Blossom Special Star Party
Alafia State Park, Lithia, Florida. For more information, visit home1.gte.net/hoffmanc or stpeteastronomyclub.org.

MARCH 3
Triad StarFest (Tri Star)
Guilford Technical Community College, Jamestown, North Carolina. For more information, visit technet.gtcc.cc.nc.us/comserv/cline/tristar.htm.

MARCH 14–18
Kisatchie Star Party
Kisatchie National Forest, Natchitoches, Louisiana. For more information, visit www.bro.lsu.edu/bras/kisatchie.html.

MARTY HARRIS/McDONALD OBSERVATORY

TEXAS STAR PARTY ATTENDEES can tour the McDonald Observatory's Otto Struve Telescope (center), Harlan J. Smith Telescope (right), and the Hobby-Eberly Telescope (left).

MARCH 16–18
Tennessee Spring Star Party
Fall Creek Falls State Park, Pikeville, Tennessee. For more information, visit www.cumberlandastronomicalsociety.org.

APRIL 13–17
Delmarva Stargazers Club Star Gaze
Tuckahoe State Park, Queen Anne, Maryland. For more information, visit www.delmarvastargazers.org.

APRIL 20–22
South Jersey Astronomy Club Spring Star Party
Belleplain State Forest, near Woodbine, New Jersey. For more information, visit hometown.aol.com/sjastroc/spring.html.

MAY 13–20
Texas Star Party
Prude Ranch, Ft. Davis, Texas. For more information, visit www.texasstarparty.org.

MAY 17–20

Cherry Springs Star Party

Cherry Springs State Park, Galeton, Pennsylvania. For more information, visit www.cherrysprings.org.

MAY 25–28

Riverside Telescope Makers Conference Astronomy Expo

Camp Oakes, near Big Bear City, California. For more information, visit www.rtmcastronomyexpo.org. ▣

CONTACT INFORMATION

Please submit club announcements 5 months in advance to Coming Events, *Astronomy*, P. O. Box 1612, Waukesha, WI 53187, or jmcgovern@astronomy.com. Also use this e-mail address to submit your events for our online calendar.

STATEMENT OF OWNERSHIP, MANAGEMENT, AND CIRCULATION
(Required by 39 USC 3685)

1. Publication title: ASTRONOMY
2. Publication No.: 531-350
3. Filing date: October 1, 2006
4. Issue frequency: monthly
5. Number of issues published annually: 12
6. Annual subscription price: $42.95
7. Complete mailing address of known office of publication: 21027 Crossroads Circle, Waukesha, WI 53186, Waukesha County.
8. Complete mailing address of headquarters or general business office of publisher: same
9. Publisher: Kevin Keefe, 21027 Crossroads Circle, Waukesha, WI 53186. Editor: David J. Eicher, same. Managing Editor: Dick McNally, same.
10. Owner: Kalmbach Publishing Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187-1612. Stockholders owning or holding 1 percent or more of total amount of stock are: Gerald B. Boettcher, 8041 Warren Ave., Wauwatosa, WI 53213; Ruth H. O. Darragh, 1200 W. 3rd St., Waterloo, IA 50701; Harold Edmonson, 6021 N. Marmora Ave., Chicago, IL 60646-3903; Laura & Gregory Felzer, 222 E. Michigan St., Ste. 10, Milwaukee, WI 53202; Susan E. Fisher, 50 Puu Anoano #1502, Lahaina, HI 96761; George A. Gloff, c/o Ted & Lois Stuart, 1873 Frays Mill Rd., Ruckersville, VA 22968; Elizabeth K. Grunden, 14102 Seagler Springs Lane, Houston, TX 77044; Linda H. Hanson, 363G Bateman Circle S., Barrington Hills, IL 60010; George F. Hirschmann Trust, 363G Bateman Circle S., Barrington Hills, IL 60010; James & Carol Ingles, P. O. Box 2161, Waukesha, WI 53187; Charles A. Kalmbach, 7435 N. Braeburn Lane, Glendale, WI 53209; Lois P. Kalmbach, 7435 N. Braeburn Lane, Glendale, WI 53209; Sydney & Ruth Klinka Kalmbach Family Trust, P. O. Box 727, Pebble Beach, CA 93953-0727; Kalmbach Profit Sharing/401K Savings Plan & Trust, P. O. Box 1612, Waukesha, WI 53187-1612; James J. King, 3874 Quail Ridge Dr., Boynton Beach, FL 33436; Mahnke Family Ltd. Partnership/Trust, 1979 Discovery Village Lane, Gold River, CA 95670-7279; Mundschau Revocable Trust, N24 W30420 Crystal Springs Dr., Pewaukee, WI 53072-4275; Daniel & Mary Murphy, 705 Heathery Ln., Naples, FL 34108; Robclif, Inc., P. O. Box 3597, Reno, NV 89505; David M. Thornburgh Trust, 420 W. San Marino Dr., Miami Beach, FL 33139-1136.
11. Known bondholders, mortgagees, and other security holders owning or holding 1 percent or more of total amount of bonds, mortgages, or other securities: N/A
12. Tax status (for completion by nonprofit organizations authorized to mail at nonprofit rates): N/A
13. Publication title: ASTRONOMY
14. Issue date for circulation data below: September 2006
15. Extent and nature of circulation:

	Average no. copies each issue during preceding 12 months	No. copies of single issue published nearest to filing date
a. Total number of copies (net press run)	198,041	197,022
b. Paid and/or requested circulation		
1. Paid/requested outside-county mail subscriptions	103,508	104,864
2. Paid in-county subscriptions	-0-	-0-
3. Sales through dealers and carriers, street vendors, counter sales, and other non-USPS paid distribution	31,739	32,260
4. Other classes mailed through the USPS	-0-	-0-
c. Total paid and/or requested circulation [sum of 15b (1),(2),(3),and(4)]	135,247	137,124
d. Free distribution by mail (samples, complimentary, and other free)		
1. Outside-county	-0-	-0-
2. In-county	-0-	-0-
3. Other classes mailed through the USPS	70	64
e. Free distribution outside the mail (carriers or other means)	169	500
f. Total free distribution (sum of 15d and 15e)	239	564
g. Total distribution (sum of 15c and 15f)	135,486	137,688
h. Copies not distributed	62,555	59,334
i. Total (sum of 15g and h)	198,041	197,022
j. Percent paid and/or requested circulation (15c divided by 15g times 100)	99.82%	99.59%

16. Publication of Statement of Ownership: Publication required. Printed in the January 2007 issue of this publication.
17. I certify that all information furnished on this form is true and complete. Michael Barbee, Corporate Circulation Director. Date: September 29, 2006.

Get more of what you enjoy!

Exclusive for magazine readers
Go beyond the page with our online-extra stories!

Online extras take you deeper inside the subjects you read about in Astronomy. Take a closer look at topics that span the universe – for magazine readers only!

Visit **www.Astronomy.com** and register with code **UK7S1A** for access to premium content through February 1, or subscribe for unlimited access!

Woodland Hills Telescopes

Order: Mon-Sat • 9-6 PT
Toll Free: 888.427.8766
P: 818.347.2270
F: 818.992.4486
WHtelescopes.com

5348 Topanga Canyon Blvd.
Woodland Hills, CA 91364

MEADE

ETX
LX90 GPS
RCX
LX200 GPS

CELESTRON

CGE
Nexstar GPS
Nexstar 8i SE
CPC

CORONADO

We now have the new Personal Solar Telescope, P.S.T.-CaK, in our store. It allows you to see and photograph solar flares and prominences safely. **$499**

The MAXSCOPE 40 Telescope with BF10 – New Low Price **$1699**

LOSMANDY

- New Gemini goto in stock
- G11 Mount with dual axis drive
- GM-8 mount, dual axis drive

TeleVue Visionary
Eyepieces with FREE SHIPPING!

Plossl 8, 11, 15mm..................$85
20, 25mm........................$99
32, 40mm........................$119
55mm..............................$235
Radian 3, 4, 5, 6, 8, 10, 12, 14, 18.0mm...............$250
Zoom Nagler 2-4mm............$395
3-6mm..............................$385
Click 8-24mm click stop..........$215

Panoptic 41mm........................$510
35mm.......$380 27mm......$345
24mm.......$310 22mm......$285
19mm.......$245 15mm......$215
Nagler Type 5 31mm............$640
20mm.........$450 16mm.......$330
Nagler Type 4 12mm............$365
17mm......$395 22mm............$480
Nagler Type 6 13, 11, 9, 7.5, 3.5 and 2.5mm..............$290
Zoom Dioptrix 8-24mm........$240

Canon KNOW HOW™ Cameras, Binoculars
CELESTRON
Denkmeier
JMI
MEADE
MoonLite Telescope Accessories
ORION
SBIG ASTRONOMICAL INSTRUMENTS
SB Software Bisque
Starry Night
STELLACAM
TAKAHASHI
Vixen
WILLIAM OPTICS

WIN A FREE TELESCOPE! ENTER AT www.whtelescopes.com

DENKMEIER

The New Revolutionary
2" Star Diagonal
For Your SCT

Superbly crafted, featuring
a 1/10th wave mirror and
fully multi-coated lenses.

Prices start at
$389 + S / H

Includes a built-in Fully
Multi-Coated 2" Reducer
and a 2" Barlow and
everything that you need
for attaching it to
an 8" or larger SCT.

Turns any eyepiece into
three eyepieces, instantly.
Example: A 20mm 2"
82 degree eyepiece
would perform as a
10mm/20mm/32mm
2" 82 degree eyepiece!

An Expert's Opinion
"The images that it produces are good enough to make spending lots of money on large sets of expensive eyepieces unnecessary and frankly a little bit silly....what makes this a groundbreaker is the way it changes your observing routine for the better."
– *Rod Mollise, Author of Choosing and Using a Schmidt Cassegrain Telescope*

Call us toll-free or visit our Online-Store
We accept all major credit cards
Click on "Power x Switch
Star Diagonal For SCTs"
We ship internationally

866-340-4578
DENKMEIER.COM

**TELESCOPE KITS, LENSES, ACHROMATS
MIRRORS, MIRROR BLANKS,
ALUMINUM COATINGS & ACCESSORIES**
BUY DIRECT ★ DO IT YOURSELF

Stock & Custom mirrors and molded mirror blanks, diagonals, parts made from Pyrex, optical glasses, fused silica, quartz and other low expansion ceramic materials. Telescope accessories, do-it-yourself books.
Write, call, fax or e-mail for catalog

NEWPORT GLASS WORKS, LTD.
P.O. Box 127
Stanton, CA 90680
PH: (714) 484-8100
FAX: (714) 484-8181
E-mail: astronomy@newportglass.com
Web: http://www.newportglass.com

Abbeville
Telescope
Company
We're Focused on the best

ATC makes choosing the right equipment easy because we offer only the finest. You will always be happy owning the best.

TeleVue – Vixen – Coronado

At ATC the best is more affordable than you think. For as little as $85, the TeleVue Plössl is a bargain in a premium quality eyepiece. At that price there is no reason to start with anything else and your appreciation of TeleVue quality will only grow with time. This is the kind of value ATC seeks out for our customers. TeleVue telescopes are in stock. Visit ATC to see and feel what makes these "heirloom" quality instruments.

TeleVue
Visionary

Visit Georgia's only stocking TeleVue dealer.
Call Gordon and Darlene today for personal advice on the right equipment for you!
www.AbbevilleTelescopeCo.com - gphoto1@alltel.net
351 W. College St - Abbeville, GA 31001 - (229) 467-2878

**Dielectric.
Quartz.
1/10th
wave.
*Guaranteed!***

$189.95

Each **Astronomy Technologies** quartz dialectric 2" mirror diagonal comes with a Zygo interferogram showing its 1/10th wave or better surface accuracy *after coating!*

The premium **Astro-Tech** diagonals have durable 99% reflectivity *46-layer dielectric* first surface mirror coatings, a non-marring compression ring eyepiece holder, a 1.25" compression ring eyepiece adapter, and your choice of either a standard 2" nose piece for refractor use at $189.95 (shown above) or a threaded ring to connect to a Schmidt-Cassegrain rear cell at $199.95.

ASTRO-TECH
from Astronomy Technologies
Astro-Tech products are available at these dealers:
www.astronomics.com
www.highpointscientific.com
www.blueplanetoptics.com
in Europe, **www.aleph-lab.com**

SmartAstronomy.com
***A Hubble For
Your Backyard
FREE***
***TeleGizmos
Scope Cover***
888.291.6577

Wicked Laser Pointers
Green, Red, and Blue Laser Pointers
**Enough power to pop balloons,
ignite matches, and light cigarettes!**
Order online at: **www.wickedlasers.com**

EYEPIECES / ACCESSORIES
There is a universe full of things to see.
KNIGHT OWL EYEPIECES

Ultra-
wide
Specials!

Call for specials on Lumicon and William Optics Products

Ultra-wide Angle Eyepieces - 80-deg

2" Eyepieces
30 mm - $73.95
20 mm - $84.95
15 mm - $54.95

1.25" Eyepieces
16 mm - $44.95
11 mm - $41.95

Great Prices!
< Call us with Coupon #A017 for discounts >
Contact us and see our website:
www.owlastronomy.com
owl1@owlservices.com
Toll-free Phone Number:
1-888-OWL-WARE 10 AM to 6 PM EST M-F

MoonLite Telescope Accessories

2" Refractor focusers
SCT focusers
Large format Refractor focusers
Newtonian focusers

Motor focus
dual rate
auto brake
tri-knob, shaft lock
compression ring
pc interface
high res stepper motor
custom anodized color
100% made in USA
www.focuser.com
570-275-7935

ECLIPSE SHADES™
Safe Solar Viewers
Custom Imprinting Available

SAFE FOR DIRECT SOLAR VIEWING
CE
Certified

The ultimate in protection from harmful solar radiation. Lenses are made of our exclusive scratch resistant optical density 5, "Black Polymer" material. Eclipse Shades filter out 100% of harmful ultra-violet, 100% of harmful infrared, and 99.999% of intense visible light. These premium filters create a sharper ORANGE colored image of the sun.

Rainbow Symphony, Inc.
6860 Canby Ave. #120, Reseda, CA 91335
(818) 708-8400 • Fax (818) 708-8470
eclipse@rainbowsymphony.com
www.rainbowsymphony.com/soleclipse.html

DBA Astronomy Products
Our Own Best Selling 8"-10"-12"
Deep Space Observer Telescopes
- 2 Speed Crayford focuser
- Roller bearing and Teflon
- Many more standard features!
10" DSO $579 w/ Free Shipping!
Sky Sweeper 25 x 100
Astronomy Binoculars
- Broadband multi-coated lenses and BAK4 Prisms
- Waterproof
$349 in stock
(Aluminum case included)
989-662-6924
www.dbaAstronomy.com

So Many Ads. . .,
How Does One Choose?
ONE-STOP SHOPPING
For All Of Your Astronomy, Digital Photography and Consumer Electronics Needs
focus
CAMERA & VIDEO
MEADE • LEICA
CELESTRON
TELEVUE • CANON
BUSHNELL • ZEISS
HQ for SONY Alpha DSLR System
SONY
α
like.no.other
SERVING CUSTOMERS HONESTLY SINCE 1966
TOLL-FREE
877.883.5937
www.focuscamera.biz

www.zerotoys.com
NEW FEATURES
AMAZING Toys for SPACESHIP EARTH
Toll Free: 866-937-6869

Don't miss an issue of the
world's best-selling
Astronomy magazine!
- Spectacular photography
- Expert observing tips
- Readable, user-friendly articles
- Timely science reporting
- Monthly pull-out star maps
- *And much more!*

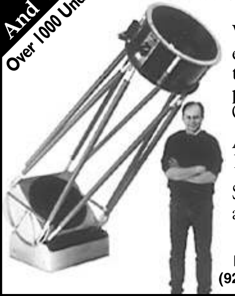
Can you imagine...
Owning your own fun
Astronomy Delight! franchise
with unlimited profit potential?
Enormous untapped markets
Virtually no overhead - Co-op advertising
No royalties - Full astronomy equipment setup
Veterans discounts - Work your own schedule
Income range well over $100 - $500 per hour!
Even the ability to sell quality telescopes from premiere manufacturers! All for only
$9,500.00!
ACT NOW! Avoid possible 2007 price increases
Astronomy Delight!™
www.astronomydelight.com 845-229-5572
MI - CA - PA - Tri-State NY- GA - MO - NC

The ONLY Green Laser Designed Specifically for Astronomy!
Now with easy-aim telescope mount!
- Easily mounts to any telescope
- Can run for hours
- Designed to operate in cool weather
- 4 other models to choose from
Thousands sold—fast delivery & we ship worldwide.
Visit www.LuckyDuck.com/astronomymag or call toll-free 877-388-7362 for your special Astronomy Magazine discount.
(Shown here with one of several available telescope mounts—beam is simulated)
Jasper *The next generation green laser.*

STELLARVUE®
HANDCRAFTED TELESCOPES & ACCESSORIES - TOP RATED PERFORMANCE
— SEEING IS BELIEVING —
Top rated 80/9D
Only $399
"The Stellarvue's optical prowess is especially impressive" Phil Harrington
New Nighthawk BV 80mm f-7 Aplanat Binoviewer ready - high resolution optics
Only $499
Nighthawk Next Generation 80mm ED from only $699
Our new highly rated 90mm Fluorite Apo Triplet from only $1995
New 50mm and 80mm finderscopes with all the features you have been asking for!
Top Rated SV4 and 102T Apochromatic Triplet Refractors. The best in the 4" class.
"The SV4 is one of the finest apochromats sold today."
Phil Harrington
Astronomy Magazine
October 2006
STELLARVUE®
www.stellarvue.com
11820 Kemper Road
Auburn, CA 95603
(530) 823-7796

The Original And The Best!
Over 1000 Under The Stars

OBSESSED WITH THE BEST?



We are! Nothing else comes close to the quality and performance of an Obsession.™

Apertures from 12.5 to 25 inches.

Send for free flyer and video.

PO Box 804a
Lake Mills, WI 53551
(920) 648-2328 • Fax also

OBSESSION TELESCOPES™
www.obsessiontelescopes.com

Cosmic Laser Etching

Experience the power of light on granite and marble

Visit our Web site
www.LakeMichiganTile.com

Starry Night PRO

Southeasternskies.com

All the fun stuff in one great location!!!
Raleigh, NC 919.890.4484
southeasternskies.com

Starry Night
PRO
NEW 6

We Challenge You to...

PC & MAC CD-ROM
TRUE INTERACTIVITY
Includes Autostar Version 4.x
AUTOSTAR
MEADE
MASTER AUTOSTAR®
Get it Right Before Going Out
www.maxfactory.com

Master Autostar... ALL of it !

www.maxfactory.com

For great deals, look North

We carry the complete line of SkyWatcher telescopes. Easy shipping to the U.S. & Canada

EfstonScience is Canada's #1 science and astronomy equipment dealer. Our knowledgeable staff of astronomy enthusiasts keeps our 8000 ft.² retail SuperStore jam-packed with the all the latest in hot scopes and accessories. And it is all online — shop for 1000's of products on our website at **www.telescopes.ca.** With great prices and easy shipping across North America, discover for yourself why EfstonScience has been Canada's brightest star for over 36 years, eh.

FEATURED BRANDS

- *Meade*
- *Lumicon*
- *Celestron*
- *Thousand Oaks*
- *TeleVue*
- *Vixen*
- *Pentax*
- *Orion*

NEW & USED EQUIPMENT

EfstonScience 36™ Anniversary 1970 - 2006

Proudly Canadian

EfstonScience
The Science & Astronomy SuperStore

3350 Dufferin Street, Toronto, ON, Canada M6A 3A4
(416) 787-4581 (888) 777-5255 **www.telescopes.ca**

ASTRO-PHYSICS

Experience the ultimate in quality instruments for discriminating observers and astrophotographers.

Telescopes, Go-To German Equatorials, Visual and Photographic Accessories

Unparalleled Service and Support

Experience the legend that is

ASTRO-PHYSICS!

160mm f7.5
StarFire EDF
900GTO

11250 Forest Hills Road
Machesney Park, IL 61115, USA
Ph: 815-282-1513, Fax: 815-282-9847
www.astro-physics.com

Sometimes, one plus one is equal to much more than two . .

This is one of those times

Introducing . .

CORONADO
PST

Patent Pending

Howie Glatter's Binocular Platform for the Coronado© PST - $385

Interpupillary distance adjustable from 60mm
Weatherproof Aluminum Superalloy and Stainless Steel construction

Optional Universal Astronomics alt-az Microstar mount (pictured with handle) - $187

Howie Glatter's Full Line Astronomical Collimators, SkyPointers and Brackets on the Web

Howie Glatter 3850 Sedgwick Ave #14F
Bronx, NY 10463 Tel/Fax (718) 796-3203
www.skypointer.net www.collimator.com
e-mail: howieglatter@mindspring.com

---

www.z-bolt.com

Green Lasers for
Star Pointing
Star Finders
Scope Mounting

- **Shop 20+ Green Laser Models**
- **Remote Switches for Scope Mounts**
- **Universal Laser Mount Brackets**
- **Astronomy Laser Gift Packs!!**
- **Personalize with laser engraving**
- **APC Computerized Power Output**

All major credit cards accepted; faxed PO's from universities, corporations, government agencies, and the US Armed Forces.

Beam of Light Technologies, Inc.
Toll Free: 877-801-9299
Fax: 603-309-6020

STARMASTER PORTABLE TELESCOPES
Hi Performance Dobs. Truss Mounted Scopes ranging in sizes from 8" up to 28"
2160 Birch Rd. • Arcadia, KS 66711
or Call: (620) 638-4743
9:00 am-9:00 pm C.S.T 7 days a Week.
www.starmastertelescopes.com

DslrStar
Advanced DSLR Control
- Standalone or PC remote
- AutoDark sequences
- Focus Assist
- USB, Autoguider port
Canon and Nikon
Your Astrophotography Assistant
Cercis Astro www.cercisastro.com 609-737-5120

Patented
The Spectrum Filter Wheel
The Ultimate Lunar/ Planetary Filter with 12 Colors and Barlow
scopemerchant.com
$139.95 805-750-1609
Dealer Inquires Welcome

bigbinoculars.com
Astronomical binoculars (50-150mm) and accessories at down-to-earth prices.
Toll free- 866-244-2460 (BIG-BINO)
www.bigbinoculars.com
OBERWERK FUJINON

8" f/6 • 10" f/5
12.5" f/5
14.5" f/4.3
Think Outside Of The Box
Mag 1 Instruments Portaball
Quick Set-up • Rotatable Tube
Optics by Zambuto Optics
SEE It Spin Online!
mag1instruments.com
262-785-0926

ScopeStuff
Telescope Accessories & Hardware
www.scopestuff.com
512-259-9778

DISCOVER THE SUN...
847-579-0025
www.solarscope.com

Green Laser Pointer
points out the stars
www.betapointer.com
phone 800.546.2382

VISIT US!

StarGazers
INN & OBSERVATORY
Nightly StarGazing in Private Observatory
Luxury B&B in Big Bear Lake, CA Offers Romance Under the Stars! Queen Featherbeds, Fireplaces, Candlelit Spa Tubs, Indoor Heated Pool, Sauna, Game Room, & More!
866-482-STAR (7827) www.stargazersinn.com
- Mention this ad for discount -

Telescopes.com
UP TO 50% off retail!
World's Largest Selection of Telescopes!
www.telescopes.com 1-800-303-5873

Bob's Knobs
$16 - $25 shipped worldwide
Meade, Celestron, Intes Takahashi, and more!
6976 Kempton Rd.
Centerville IN 47330
765-855-5109 USA
www.bobsknobs.com

ScopeBuggy
MAKING VIEWING EASIER
- For use with most tripods, DOBs and piers
- Load tested to 600+ pounds
- Assemble in minutes for use or storage
- Pneumatic inflated 10" tires for soft ride
- Gloss black powder coat paint
- Optional battery equipment tray
- Adjustable rear axle height, 1 1/2" to 7"
- Anodized gold wheels
- One person can move any size scope quickly and easily
- Ideal for the new Meade RCX Series
- Ideal for scopes up to 36"

$265.00
Plus S&H, Approx.
$30 Shipping USA

Patent Pending

SCOPEBUGGY
P.O. BOX 834
Elephant Butte, NM 87935
Toll Free
866-312-8449

Shipping weight 36 lbs.
shipped UPS ground

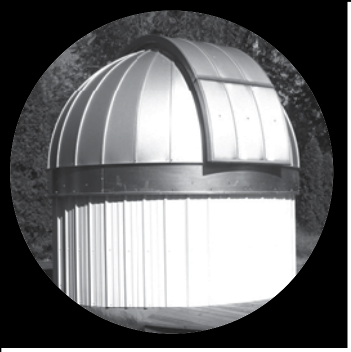
We Accept :
VISA • MASTERCARD • AMERICAN EXPRESS
PAYPAL • MONEY ORDERS • CASHIERS CHECKS

Please visit us at www.scopebuggy.com

EUROPE'S PREMIER WEBSITE
http://www.scsastro.co.uk
SCS ASTRO

SURPLUS SHED℠
SURPLUS OPTICS AND ELECTRONICS
FREE 144 PAGE CATALOG
Phone TOLL FREE:
1-877-7SURPLUS • 610-926-9226
E-Mail: SURPLUSHED@aol.com
www.SurplusShed.com
8408 Allentown Pike, Blandon, PA 19510

America's best selling Astronomy magazine!
Subscribe today!



STARDUST OBSERVATORY

PITTSFORD, NEW YORK

The ASH-DOME pictured is a 10'6" diameter, electrically operated unit. The observatory dome houses a 155 mm f/7 Astro-Physics refractor. This is a privately owned observatory and is used year-round for visual and photographic studies of the solar system and studying deep sky objects.

ASH MANUFACTURING COMPANY
P.O. Box 312
Plainfield, IL USA 60544
815.436.9403 • FAX 815.436.1032
web site: www.ashdome.com
email: ashdome@ameritech.net

ASH-DOME is recognized internationally by major astronomical groups, amateurs, universities, colleges secondary & primary schools for their performance durability and dependability. Manual or electrically operated units in sizes from 8 to 30 feet in diameter; sensibly priced. Brochures and specifications available.

BIG BANG ASTRONOMY SHOP

We're Always's Expanding!

AUTHORIZED
MEADE, ORION,
LUMICON, JMI,
ASTROZAP
DEALER

RALEIGH,
NORTH CAROLINA
866-352-2264

Home of the Time/Cost
Saving Telescope
Quick-Connect

www.BigBangAstro.com

SIRIUS OBSERVATORIES

Designed and Manufactured in Australia

We ship to anywhere in the world

- Complete observatory - 2.3m, 3.5m, 6.7m diameters
- Dome only • Completely waterproof
- Dome rotation and shutter operation
  - manual ◦ motorized
  - computerized (ASCOM compatible)
- Stainless steel fittings

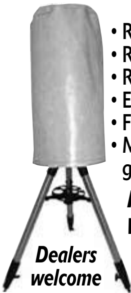
NEW - *Home Model Lower Shutter mechanism*

www.siriusobservatories.com info@siriusobservatories.com

Scope Armor Covers: starting at **$39.95**

The first line of defense for your telescope!

SCOPE ARMOR™



- Repel water
- Repel heat
- Resist scratches & dents
- Easy installation • Affordable
- Fit most Schmidt-Cassegrain scopes
- Made of durable marine/military grade materials

For details visit
www.scopearmor.com
or call ***603-743-4083***
Major Credit Cards Accepted

Dealers welcome

WOLFCAMERA

OUR EXPERTISE IS FREE!

EXPERTISE: Chuck Pisa, our staff astronomer, has 20 years experience recommending optical instruments to amateurs and professionals at our Sarasota location. You can e-mail questions to Chuck at cpisa@mindspring.com

SELECTION: We have a HUGE selection of products from telescopes, binoculars and CCD cameras to filters and eyepieces. If it's astronomy-related, we have it! We carry Meade, Celestron, TeleVue, and Apogee as well as a selection of used telescopes.

SARASOTA, FL
2069 Siesta Drive
(941) 955-3537 • (941) 366-8640 fax

The 2007 *Astronomy* calendar is here!

2007 october

PMK-ADH-06X1139RH

Striking images of dramatic celestial observations include the Tarantula Nebula, Whirlpool Galaxy M51, the Hydra Cluster, and the stunning Fox-Fur Nebula. Features data on viewing many celestial events and detailed captions composed by the staff of *Astronomy* magazine. Recognizes national holidays. 13 x 10½.

68145 • $12.95

Deep Space Mysteries
2007 CALENDAR
Astronomy

Order today!

Order online:
Astromagbooks.com
Secure online ordering available

Call 1-800-533-6644
Mon-Fri, 8:30am-5:00pm Central Time. Outside the U.S. and Canada, call 262-796-8776 x661.
Fax 262-796-1615.

To order by mail:
Send your order to Kalmbach Publishing Co., Dept. A2008, 21027 Crossroads Circle, P.O. Box 986, Waukesha, WI 53187-0986. Use chart on the right for shipping & handling charges.

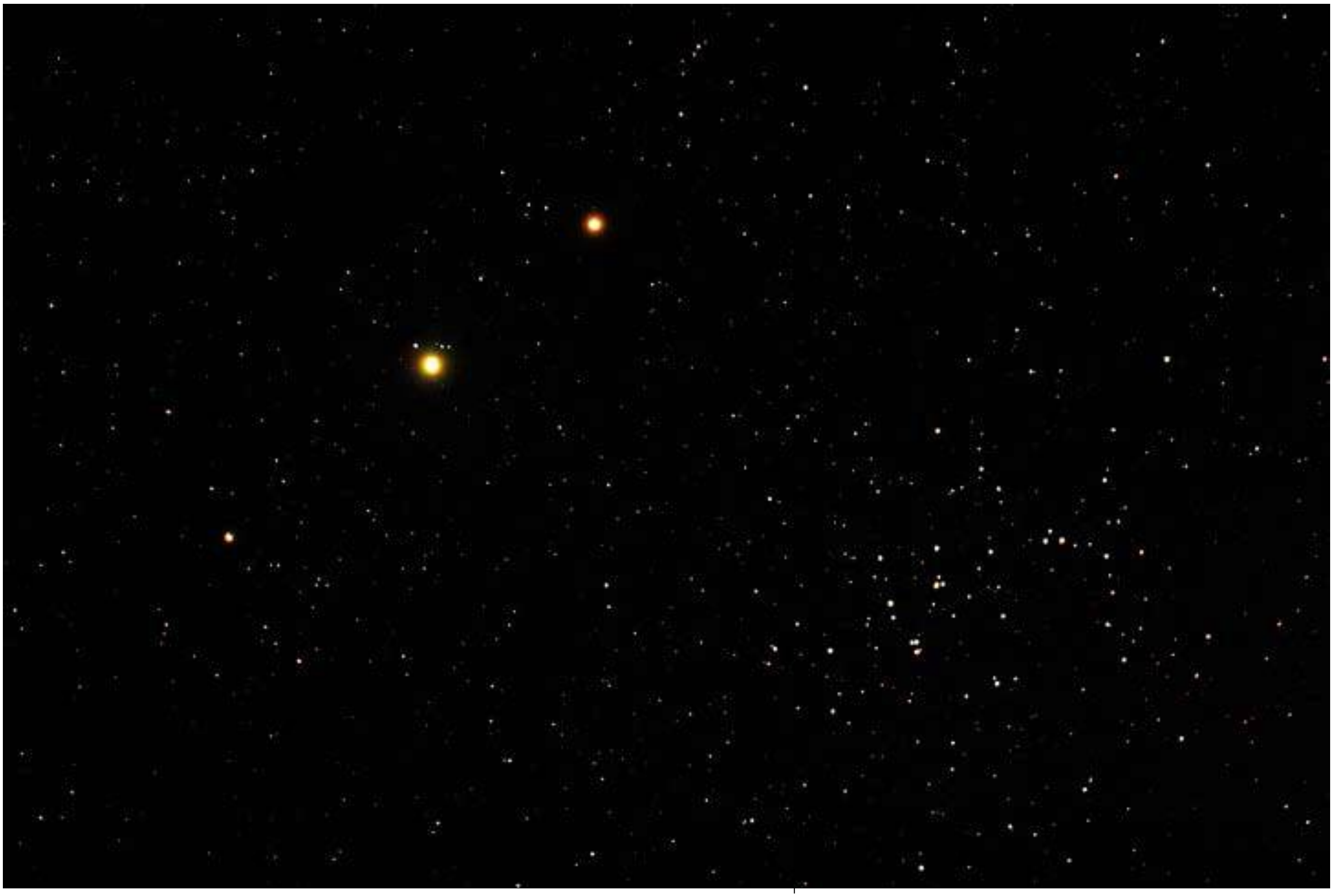
Add for shipping and handling:

Merchandise total	Add for shipping
$15.00 or less	$4.95
$15.01-30.00	$5.50
$30.01-50.00	$6.50
$50.01-75.00	$7.50
$75.01 or more	$8.50

Canada add an additional $2.00, other foreign add an additional $5.00. For Wisconsin delivery, add 5% sales tax to total; Pennsylvania add 6% sales tax to total. For delivery in Canada add 7% GST to total. Payable in U.S. funds. Checks must be drawn on a U.S. bank except for those from Canada; GST included. Make checks payable to Kalmbach Publishing Co. Prices and availability subject to change.

A2008

Reader gallery



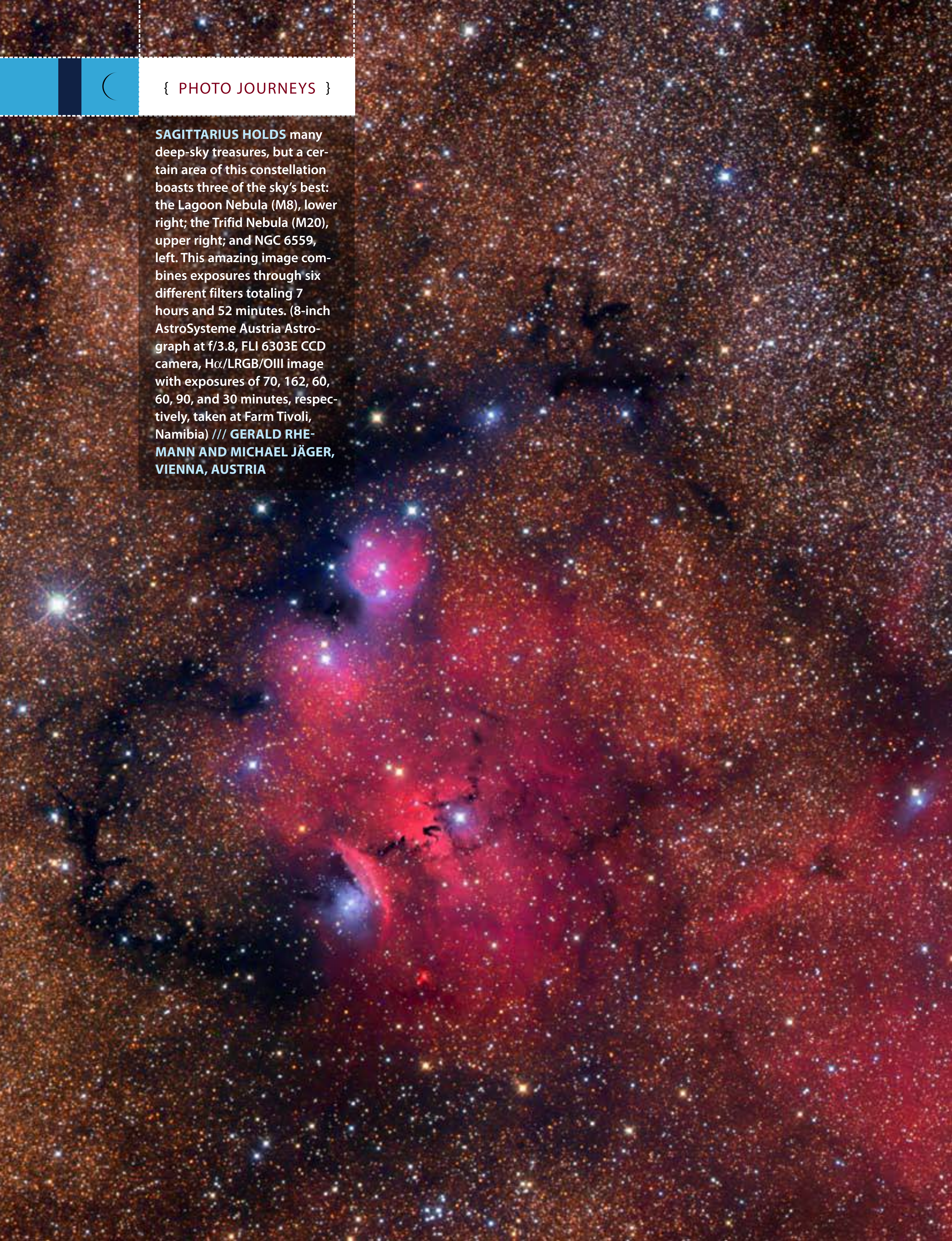
PLANETARY/DEEP-SKY GROUPING

Visitors to the Beehive

Only rarely do two bright planets congregate near a bright deep-sky object. On June 16, 2006, however, observers found both Saturn, which shines as the brightest object in this image, and Mars (upper right of Saturn) not far from the Beehive Cluster (M44) in Cancer. At 8 P.M. MST, Saturn lay 1°23' from the Beehive's center, while Mars was even closer — only 42' away. The three objects forming this group only appeared close. Mars was 211 million miles (340 million kilometers) from Earth, and Saturn lay 916 million miles (1.47 billion km) distant. Compare these distances to M44, which lies approximately 580 light-years from Earth — more than 6,500 times as far as Saturn.

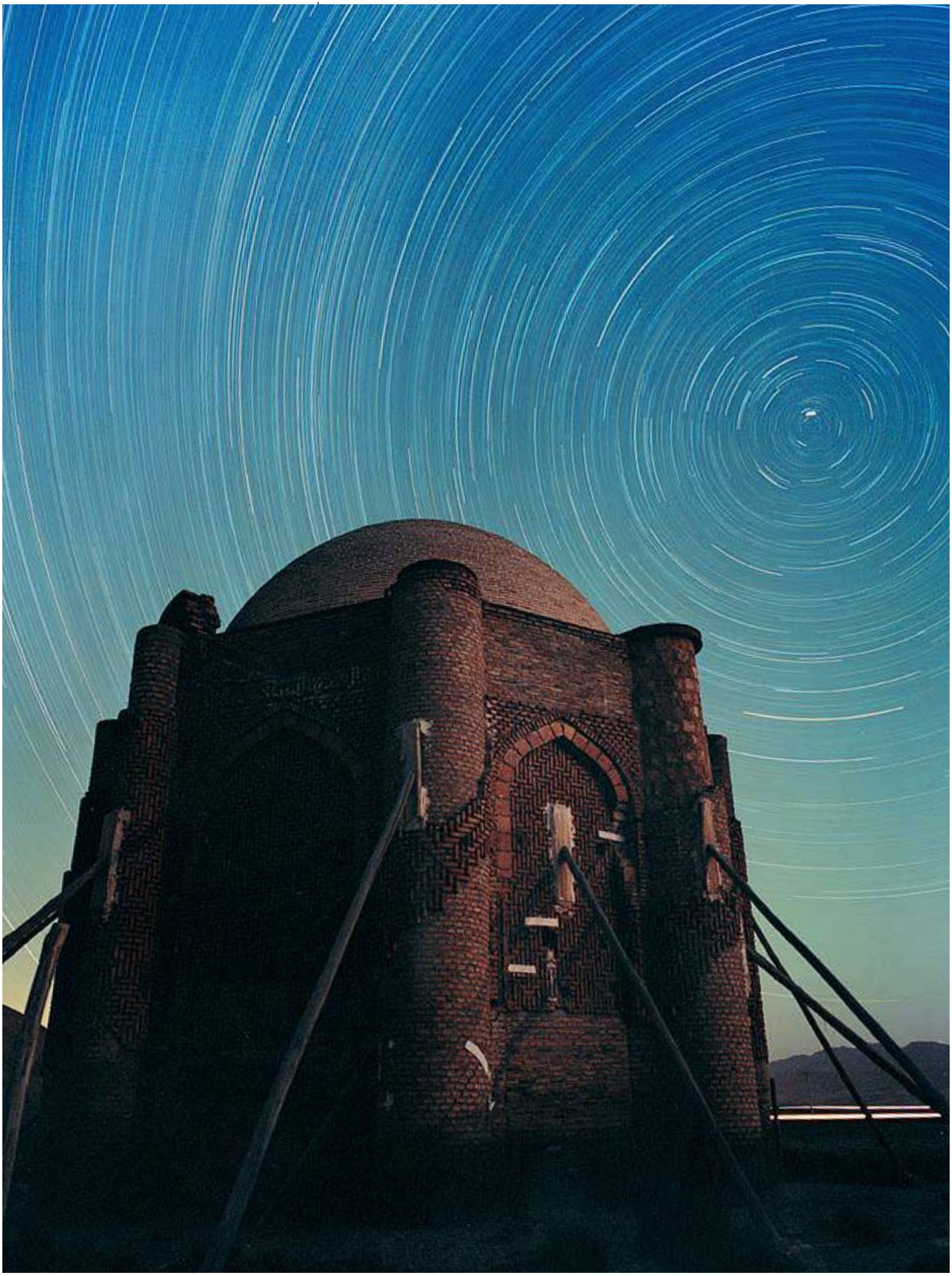
▲ **SATURN, MARS, AND THE BEEHIVE** (3.2-inch Stellarvue SV80S apochromatic refractor at f/4.74, Canon 10D digital SLR, ISO 400, 2-minute exposure, taken June 16, 2006, at 8 P.M. MST from Happy Jack, Arizona) /// **CHRIS SCHUR, PAYSON, ARIZONA**

Send your photos to: *ASTRONOMY* Reader gallery, P. O. Box 1612, Waukesha, WI 53187; e-mail to readergallery@astronomy.com. Please include your full name, date and location of image, and complete photo data: telescope, camera, film, and exposure information.



SAGITTARIUS HOLDS many deep-sky treasures, but a certain area of this constellation boasts three of the sky's best: the Lagoon Nebula (M8), lower right; the Trifid Nebula (M20), upper right; and NGC 6559, left. This amazing image combines exposures through six different filters totaling 7 hours and 52 minutes. (8-inch AstroSysteme Austria Astrograph at f/3.8, FLI 6303E CCD camera, $H\alpha$/LRGB/OIII image with exposures of 70, 162, 60, 60, 90, and 30 minutes, respectively, taken at Farm Tivoli, Namibia) /// **GERALD RHEMANN AND MICHAEL JÄGER, VIENNA, AUSTRIA**

CIRCUMPOLAR STARS revolve above one of the Kharaghan twin towers, two royal tombs located in Qazvin province, Iran, that date to the Seljuk period (1071–1243). (Mamiya 6x9 medium-format film camera, 53mm Carl Zeiss Biogon lens at f/5.6, 3.5-hour exposure, Fuji NPS 400 film) /// **OSHIN D. ZAKARIAN, TEHRAN, IRAN**



Astronomy (ISSN 0091-6358, USPS 531-350) is published monthly by Kalmbach Publishing Co., 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Periodicals postage paid at Waukesha, WI, and additional offices. POSTMASTER: Send address changes to *Astronomy*, 21027 Crossroads Circle, P. O. Box 1612, Waukesha, WI 53187–1612. Canada Publication Mail Agreement # 40010760.

ORION® OrionTelescopes.com

DAZZLING DOB DEALS!

Now Upgraded with Crayford-style 2" Focuser!

(IntelliScopes only, excluding XT6)

BONUS ACCESSORY PACK

9x50 Right-angle finder scope (6x30 Right-angle on the XT6)

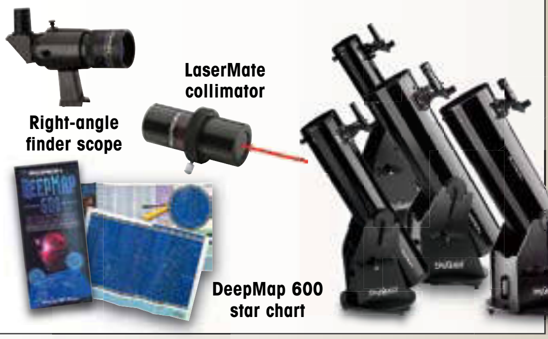
Holster for Object Locator

LaserMate collimator

FREE with Any SkyQuest IntelliScope Dobs

Dazzling Dob Deal applies to SkyQuest Classic Dobsonians too!

Bonus Accessory Pack with any SkyQuest Classic Dobs – Up to $94.90 Added Value **FREE!**


LaserMate collimator
Right-angle finder scope
DeepMap 600 star chart

ORION
ORION
ORION
SKYQUEST
SKYQUEST

SkyQuest™ XT IntelliScope® Computerized Dobsonians Including Computerized Object Locator From $479.95

FREE COLOR CATALOG!
Call toll-free
(800) 447-1001
or request it online.

ORION TELESCOPES & BINOCULARS

Everything for the Amateur Astronomer — Delivered Direct

IMAGINOVA

THE SKY will NEVER LOOK THE SAME.
MAJOR
CASSIOPEIA
LEO
Jupiter
Mars
CELESTRON
SkyScout Personal Planetarium
INTERNATIONAL CES INNOVATIONS
BEST OF INNOVATIONS 2006

SkyScout™
Personal Planetarium

www.celestron.com/skyscout

DISCOVER

The SkyScout is a revolutionary handheld device that uses advanced GPS technology with point and click convenience to identify thousands of stars, planets, constellations and more, providing an educational and entertaining tour through the night sky.

EXPLORE

Simply point the SkyScout at any star in the sky and click the "target" button. The SkyScout will tell you what object you are looking at. To locate a star or planet, select the object's name from the menu and follow the directional arrows through the viewfinder. SkyScout tells you when you are on target. It's that easy!

LEARN

Once you have targeted an object the real fun begins. The SkyScout includes entertaining and educational audio and text information, including facts, trivia, history and mythology about our most popular celestial objects. A fun learning tool for all ages, the SkyScout personal planetarium puts the knowledge of an expert astronomer in the palm of your hand.

SKYSCOUT PERSONAL PLANETARIUM $399.00

Suggested retail in U.S. Dollars. Pricing is for products ordered and shipped in the U.S.A. only.

CELESTRON®
www.celestron.com

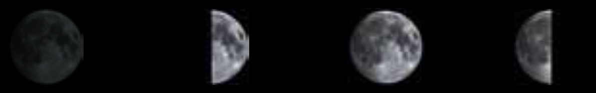
©2006 Celestron. All rights reserved. SkyScout Patented Technology.

CELESTRON PREMIER SELECT DEALER

ASTRONOMICS	800.422.7876	www.astronomics.com
OPTICS PLANET	800.504.5897	www.opticsplanet.com
TELESCOPES.COM	888.988.9876	www.telescopes.com
OCEANSIDE PHOTO AND TELESCOPE (OPT)	800.483.6287	www.optcorp.com
SCOPE CITY	800.235.3344	www.scopecity.com
ADORAMA	800.223.2500	www.adorama.com
B&H PHOTO	800.947.9970	www.bhphotovideo.com

Astronomy's 2007 guide to the night sky

LUNAR PHASES



New	First	Full	Last
		Jan. 3	Jan. 11
Jan. 18	Jan. 25	Feb. 2	Feb. 10
Feb. 17	Feb. 24	March 3	March 11
March 18	March 25	April 2	April 10
April 17	April 24	May 2	May 10
May 16	May 23	May 31	June 8
June 14	June 22	June 30	July 7
July 14	July 22	July 29	Aug. 5
Aug. 12	Aug. 20	Aug. 28	Sept. 3
Sept. 11	Sept. 19	Sept. 26	Oct. 3
Oct. 11	Oct. 19	Oct. 26	Nov. 1
Nov. 9	Nov. 17	Nov. 24	Dec. 1
Dec. 9	Dec. 17	Dec. 23	Dec. 31

All dates are for the Eastern time zone. A Full Moon rises at sunset and remains visible all night; a New Moon crosses the sky with the Sun and can't be seen.

NASA

THE MOON is Earth's nearest neighbor and the only celestial object humans have visited. Because of its changing position relative to the Sun and Earth, the Moon appears to go through phases, from a slender crescent to Full Moon. The best time to observe the Moon through a telescope comes a few days on either side of its two quarter phases. For the best detail, look along the terminator — the line separating the sunlit and dark parts.

HST

MARS grows big and bright late this year. It reaches opposition in December, when it looks best through a telescope and remains visible all night. It then passes nearly overhead around midnight for Northern Hemisphere observers. Although Mars is visible all year, it doesn't become conspicuous until late summer. Viewed through a small scope, the planet's icy poles should stand out. Other features, such as dusky plateaus, are harder to see but should show up as contrasting shades of orange and brown.

NASA/JPL/SSI

JUPITER'S dynamic face shows an alternating series of dark belts and brighter zones pocked by the Great Red Spot. Even through a small telescope, the planet's four biggest moons — Io, Europa, Ganymede, and Callisto — appear conspicuous. You may see dramatic movement of these bright moons during the course of a single night. Jupiter reaches its peak in June, when it appears biggest and brightest, although it's a fine sight from January through November.

HST

SATURN presents a beautiful view of its rings during 2007. Right now, Saturn's rings tilt approximately 15° to our line of sight, a perspective that allows us to see lots of ring detail. The dark, broad Cassini Division separates the outer A ring from the brighter B ring. The much thinner Encke Division lies near the outer edge of the A ring, and can be spotted on exceptionally good nights. You'll need a large telescope to spot the faint, innermost C ring.

Astronomy® magazine

Subscribe today! 1-800-533-6644
Visit our web site at www.astronomy.com

618170

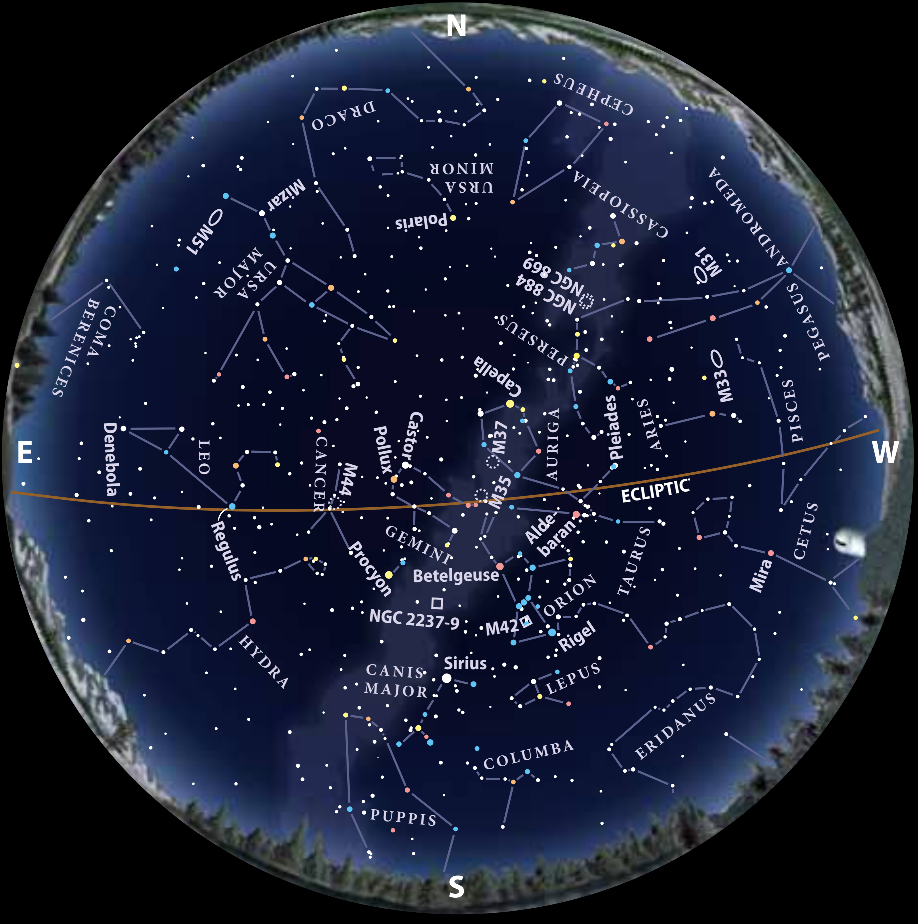
WINTER

The sky

Winter boasts the brightest stars of any season. Orion the Hunter dominates the evening sky this time of year. Its seven brightest stars form a distinctive hourglass pattern. The bright blue star marking Orion's left foot is Rigel, and the ruddy gem at his right shoulder is Betelgeuse. The three stars of the Hunter's belt point down to Sirius, the brightest star in the night sky, and up to Aldebaran, the eye of Taurus the Bull. Above Orion lies the constellation Gemini the Twins.

Deep-sky highlights

The Pleiades (M45) is the brightest star cluster in the sky. It looks like a small dipper, but it is not the Little Dipper.
The Orion Nebula (M42), a region of active star formation, is one of the showpieces through telescopes of all sizes.
The Rosette Nebula (NGC 2237–9), located 10° east of Betelgeuse, presents an impressive cluster of stars and a gaseous nebula.
M35 in Gemini the Twins is a pretty open cluster best viewed with a telescope.
Castor in Gemini is easy to split into two components with a small telescope, but the system actually consists of six stars.


N
E
W
S
DRACO
CEPHEUS
URSA MINOR
Polaris
Mizar
M51
URSA MAJOR
CASSIOPEIA
ANDROMEDA
M31
NGC 869
NGC 884
PERSEUS
Capella
COMA BERENICES
PEGASUS
M33
PISCES
ARIES
Pleiades
AURIGA
M37
M35
Castor
Pollux
M44
CANCER
LEO
Denebola
Regulus
GEMINI
ECLIPTIC
Aldebaran
TAURUS
CETUS
Mira
Procyon
Betelgeuse
NGC 2237-9
M42
ORION
Rigel
HYDRA
CANIS MAJOR
Sirius
LEPUS
ERIDANUS
COLUMBA
PUPPIS

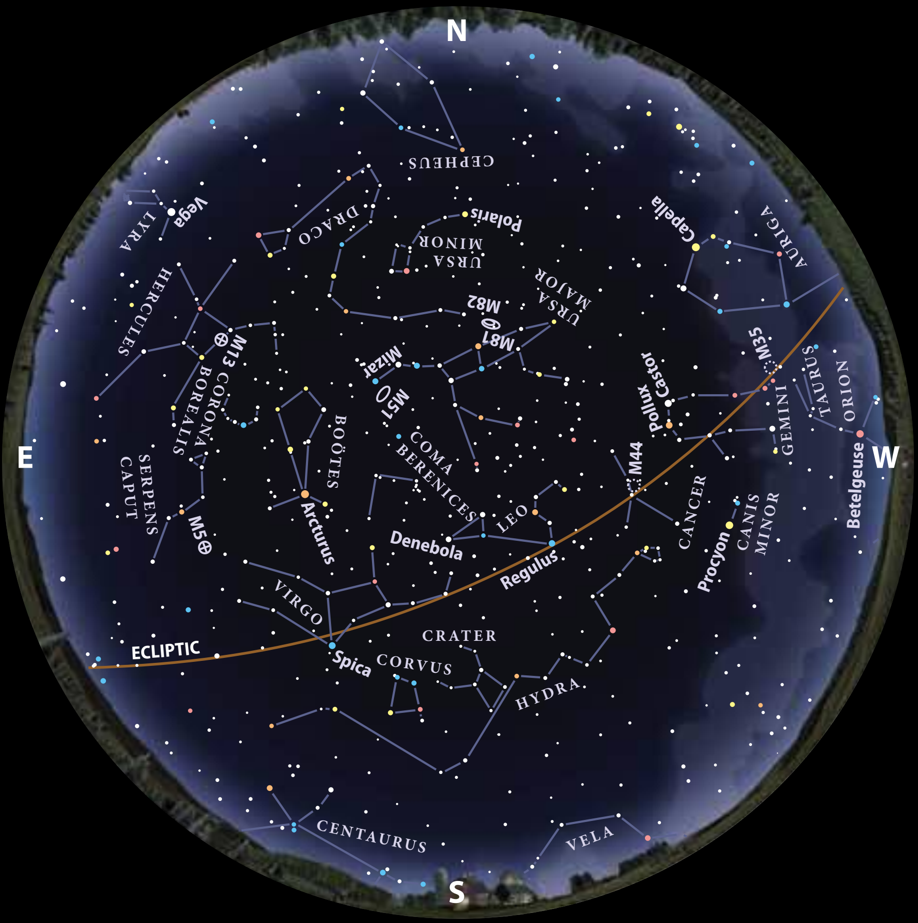
SPRING

The sky

The Big Dipper, the most conspicuous part of the constellation Ursa Major the Great Bear, now rides high in the sky. Poke a hole in the bottom of the Dipper's bowl and the water would fall on the back of Leo the Lion. The two stars at the end of the bowl, called the Pointer Stars, will lead you directly to Polaris, the North Star. From the bowl's top, simply go five times the distance between the Pointers. Spring is the best time of year to observe a multitude of galaxies. Many of these far-flung island universes, containing hundreds of billions of stars, congregate in northern Virgo and Coma Berenices.

Deep-sky highlights

The Beehive Cluster (M44) was used to forecast weather in antiquity. It is a naked-eye object under a clear, dark sky, but it disappears under less optimal conditions.
M5, a conspicuous globular cluster, lies between the figures of Virgo the Maiden and Serpens Caput the Serpent's Head.
The Whirlpool Galaxy (M51) is a vast spiral about 30 million light-years away.
M81 and **M82** in Ursa Major form a pair of galaxies that can be spotted through a low-power eyepiece.


N
E
W
S
CEPHEUS
Vega
LYRA
DRACO
URSA MINOR
Polaris
Capella
AURIGA
HERCULES
M82
M81
URSA MAJOR
M13
CORONA BOREALIS
Mizar
M51
M35
GEMINI
TAURUS
ORION
Castor
Pollux
SERPENS CAPUT
M5
BOÖTES
Arcturus
COMA BERENICES
M44
CANCER
Betelgeuse
Denebola
LEO
Regulus
Procyon
CANIS MINOR
VIRGO
ECLIPTIC
Spica
CRATER
CORVUS
HYDRA
CENTAURUS
VELA

2007 EVENTS

February 7 Mercury is at greatest eastern elongation

February 10 Saturn is at opposition

March 3 Total lunar eclipse

March 18 Partial solar eclipse (Alaska and Asia)

May 30 Asteroid Vesta is at opposition

June 2 Mercury is at greatest eastern elongation

June 5 Jupiter is at opposition

June 8 Venus is at greatest eastern elongation

June 19 Pluto is at opposition

August 13 Perseid meteor shower peaks

August 13 Neptune is at opposition

August 28 Total lunar eclipse

September 9 Uranus is at opposition

September 11 Partial solar eclipse (southern South America)

October 28 Venus is at greatest western elongation

November 8 Mercury is at greatest western elongation

November 9 Asteroid Ceres is at opposition

November 17 Leonid meteor shower peaks

December 14 Geminid meteor shower peaks

December 24 Mars is at opposition

◌ Open cluster
⊕ Globular cluster
□ Diffuse nebula
⌖ Planetary nebula
⬭ Galaxy

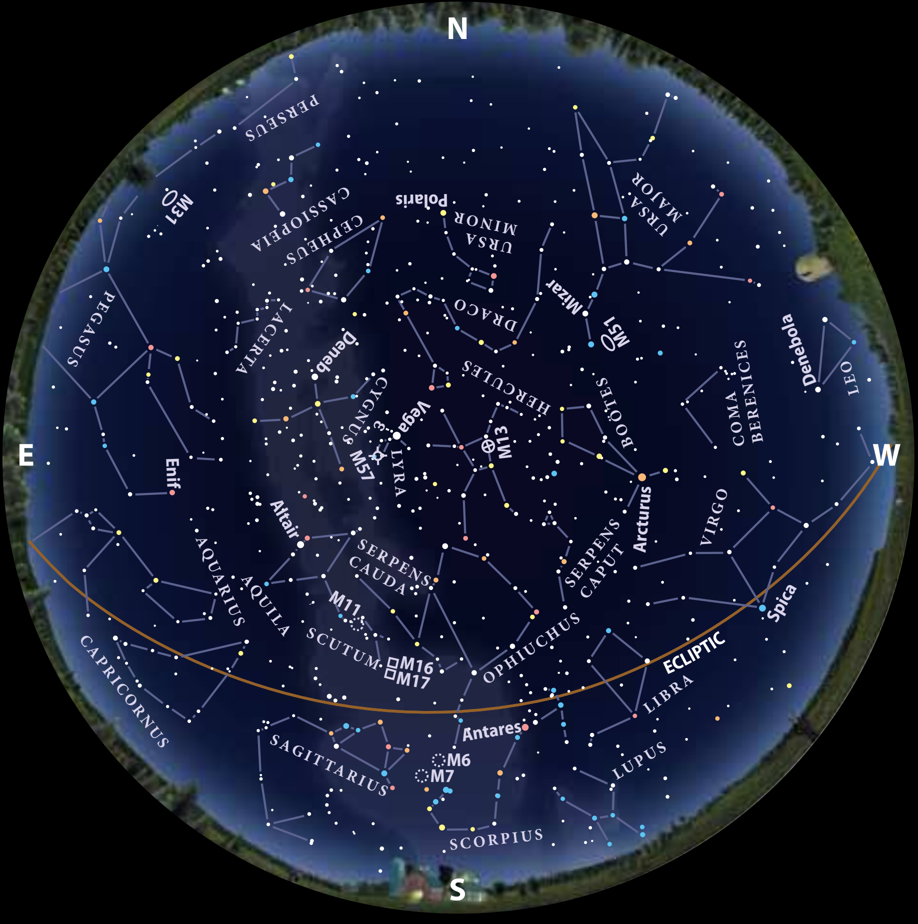
SUMMER

The sky

High in the sky, the three bright stars known as the Summer Triangle are easy to spot. These luminaries — Vega in Lyra, Deneb in Cygnus, and Altair in Aquila — lie near the starry path of the Milky Way. Following the Milky Way south from Cygnus, we find the center of our galaxy in the constellation Sagittarius the Archer. Here, you will find countless star clusters and glowing gas clouds. Just west of Sagittarius lies Scorpius the Scorpion, which contains the red supergiant star Antares as well as M6 and M7, two brilliant clusters that look marvelous at low power.

Deep-sky highlights

The Hercules Cluster (M13) contains nearly a million stars and is the finest globular cluster in the northern sky.
The Ring Nebula (M57) looks like a puff of smoke through a medium-size telescope.
The Omega Nebula (M17) looks like the Greek letter of its name through a telescope at low power. This nebula also is called the Swan.
The Wild Duck Cluster (M11) is a glorious open star cluster. On a moonless night, a scope will show you more than fifty stars.


N
E
W
S
PERSEUS
M31
CASSIOPEIA
CEPHEUS
Polaris
URSA MINOR
URSA MAJOR
PEGASUS
LACERTA
DRACO
Mizar
M51
Denebola
LEO
Deneb
CYGNUS
Vega
LYRA
M57
HERCULES
M13
BOÖTES
COMA BERENICES
Enif
Altair
Arcturus
VIRGO
AQUARIUS
AQUILA
SERPENS CAUDA
SERPENS CAPUT
M11
SCUTUM
M16
M17
OPHIUCHUS
ECLIPTIC
Spica
LIBRA
CAPRICORNUS
SAGITTARIUS
Antares
M6
M7
LUPUS
SCORPIUS

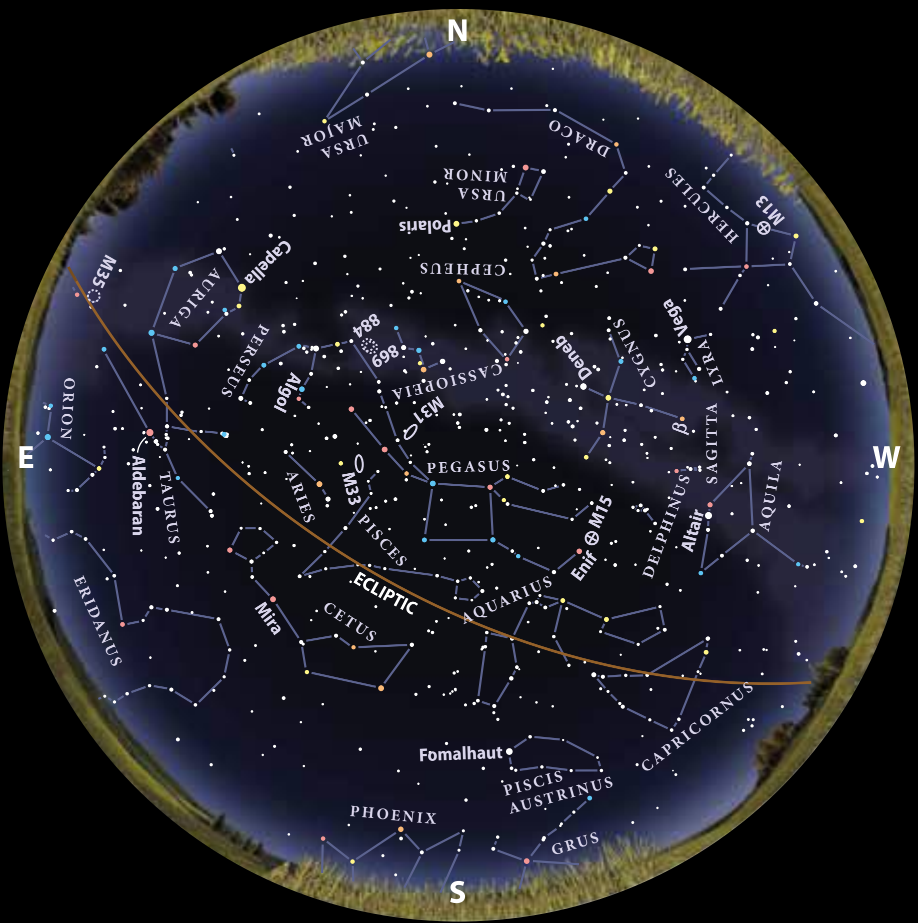
AUTUMN

The sky

The Big Dipper swings low this season, and from parts of the southern United States, it even sets. With the coming of cooler nights, Pegasus the Winged Horse rides high in the sky as the rich summer Milky Way descends in the west. Fomalhaut, a solitary bright star, lies low in the south. The magnificent Andromeda Galaxy (M31) reaches its peak nearly overhead on autumn evenings, as does the famous Double Cluster. Both of these objects appear as fuzzy patches to the naked eye under a dark sky.

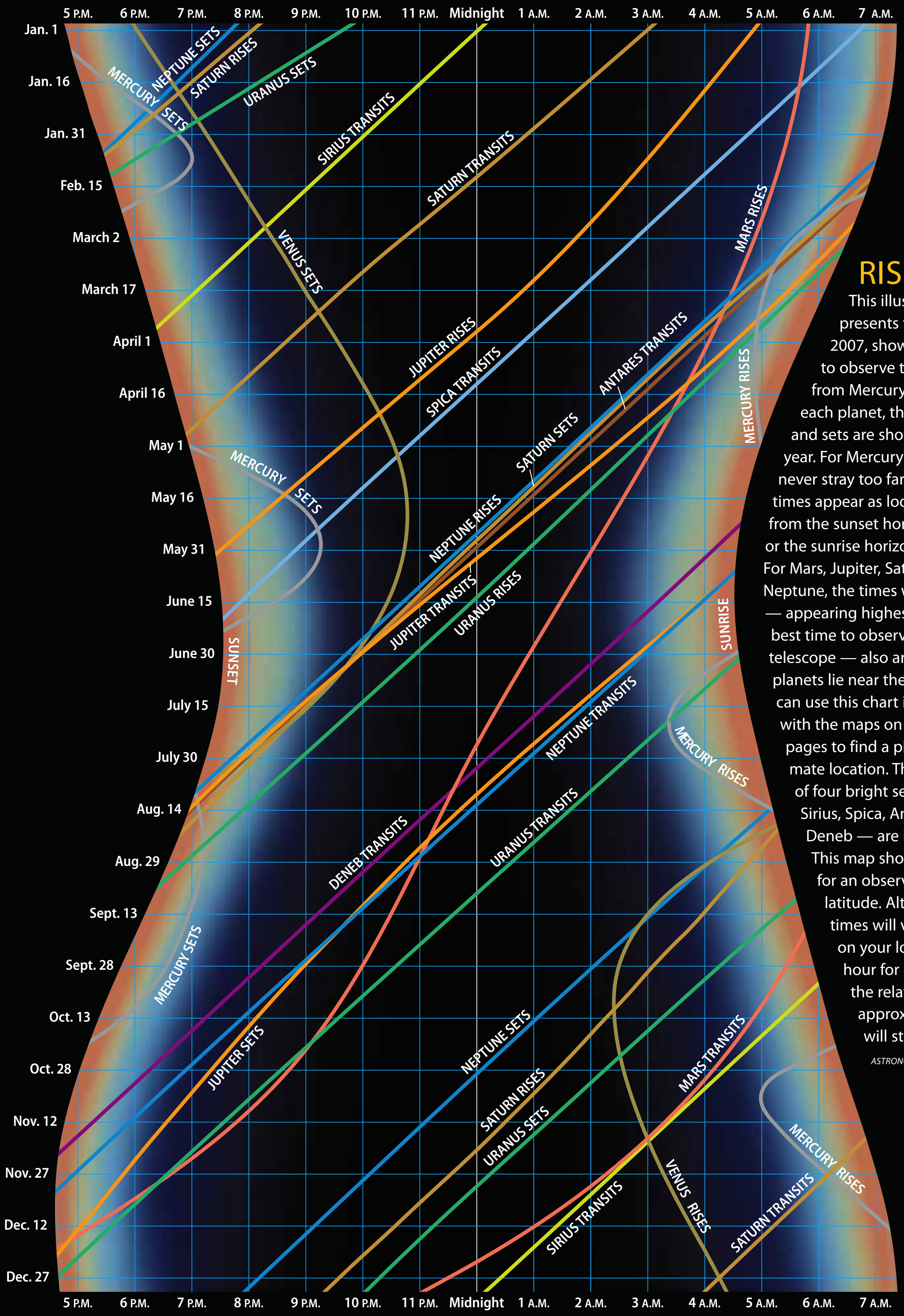
Deep-sky highlights

The Andromeda Galaxy (M31) is the brightest naked-eye object outside our own galaxy that is visible in the northern sky.
The Double Cluster (NGC 869 and NGC 884) in Perseus consists of twin open star clusters. It's a great sight through binoculars.
M15 in Pegasus is a globular cluster containing hundreds of thousands of stars, many of which can be glimpsed with a medium-size telescope.
Albireo (Beta [β] Cygni), the most beautiful double star in the sky, is made up of stars colored sapphire and gold.


N
E
W
S
URSA MAJOR
DRACO
URSA MINOR
Polaris
HERCULES
M13
CEPHEUS
M35
Capella
AURIGA
PERSEUS
884
869
CASSIOPEIA
Deneb
CYGNUS
Vega
LYRA
Algol
M31
ANDROMEDA
ORION
Aldebaran
TAURUS
ARIES
M33
PEGASUS
β
SAGITTA
AQUILA
PISCES
M15
DELPHINUS
Altair
Enif
ERIDANUS
ECLIPTIC
Mira
CETUS
AQUARIUS
Fomalhaut
PISCIS AUSTRINUS
CAPRICORNUS
PHOENIX
GRUS

STAR MAPS BY *ASTRONOMY*: ROEN KELLY

Astronomy magazine



RISE & SET

This illustration graphically presents the night sky for 2007, showing the best times to observe the major planets, from Mercury to Neptune. For each planet, the times when it rises and sets are shown throughout the year. For Mercury and Venus, which never stray too far from the Sun, these times appear as loops coming up from the sunset horizon (on the left) or the sunrise horizon (on the right). For Mars, Jupiter, Saturn, Uranus, and Neptune, the times when they transit — appearing highest in the sky and the best time to observe them through a telescope — also are shown. All the planets lie near the ecliptic, so you can use this chart in conjunction with the maps on the previous pages to find a planet's approximate location. The transit times of four bright seasonal stars — Sirius, Spica, Antares, and Deneb — are included as well. This map shows local times for an observer at 40° north latitude. Although exact times will vary depending on your location (add 1 hour for daylight time), the relative times and approximate positions will stay the same.

ASTRONOMY: RICK JOHNSON